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## Waste of Water in the City of New York.

It is most natural that those who believe a large waste of public water to exist in New York City should take this particular time to comment upon it in connection with the proposed construction of necessary works for an additional supply. So much has been said on this subject that there may be a public impression not justified by the facts of the case. It was said by some of the opponents of the plan for an additional supply, at the public hearings at Kingston, 'that if the waste of water now taking place should be pre-

vented the amount saved would be sufficient to give the city all it needs for a number of years to come. There are instances of the daily press of the city not only sharing but advocating the same views.

If the preventable waste in the City of New York is nearly as much as these statements indicate it would certainly be the part of wisdom for the city to cure such waste rather than spend great sums of money for more water to be similarly wasted. If, on the other hand, the preventable waste is but moderate in amount and of such comparatively small quantity that it is impracticable to secure any reasonable diminution of it without years of effort, it would be dangerous folly to relax to any extent the most vigorous efforts to secure an additional supply. This subject is one which should not be treated by the loose methods of impressionists nor should statements based upon isolated facts having no real bearing on the broad question of waste be seriously considered. The subject is beset with difficulties enough at the best, and its true dimensions cannot be reached through any other means than rational and cool analysis, coupled with the results of absolutely reliable investigations sufficiently comprehensive to cover the wide variety of conditions existing in the greatest city in the country.

There have been two such investigations, one by Mr. John R. Freeman of a general character undertaken five or six years ago for the comptroller of the city. Mr. Freeman had neither the time nor the means at his command to make a detailed investigation as to the amounts of water required by the different classes of consumption. He made measurements of the night flow into the distribution system and obtained results which indicated an inordinately high rate of consumption between the hours of 2 and 4 a. m. which he believed, from the available data, could only be accounted for by a large waste. His work was most admirably done and the results were of unusual value. The other investigation was made by Mr. N. S. Hill, Jr., chief engineer of the Department of Water Supply, Gas & Electricity, in co-operation with the Commission on Additional Water Supply during 1902-3, and was of a much more detailed character, extending over a greater period of time and was carried in many cases even into the use of water in various classes of buildings and to a house-to-house inspection of plumbing in selected districts. A high night consumption similar to that observed by Mr. Freeman was found in these latter investigations. Twelve representative districts in the Boroughs of Manhattan and the Bronx were selected so that the flow of water into them could be accurately measured by the pitometer. The use of water within these districts was carefully observed. In this manner the water supplied to these various districts was accounted for with at least an approach to close approximation in most cases. The results can be found in the report of the Commission on Additional Water Supply. It is only necessary to state here that the aggregate area of the districts covered amounted to nearly one-eighth of the entire area of Manhattan and the Bronx with a population of a little over 500,000 people.

It was found that in the wealthy Murray Hill residential district, the consumption per head of population amounted to over 175 gal. per day. The consumption, however, in one of the east-side tenement districts fell to 37 gal. per head per day. In one dense office district below Fulton St. the consumption per head of resident population per day rose to 860 gal., but by allowing for the transient office population this consumption fell to 83 gal. per head of total population per day. It was further found that a transient population of not far from 600,000 people entered and departed from the Borough of Man-

hattan each day. Careful measurements in what may be considered an average representative household with plumbing in good order and where the habit of daily baths prevailed showed the purely domestic consumption per member of family per day varied from 65 to 75 gal. It was further found during these investigations that in some portions of the city the volume of tankage, that is, the capacity of tanks or small reservoirs, used in buildings of all classes, has a very large aggregate, the average single tank capacity in many buildings being as much as 1,500 gal. The filling of this tank at night and the further fact that the night use of water is much greater than has frequently been supposed account largely for the observed high rate of flow in the mains at night.

The careful house-to-house inspection of plumbing in some districts appeared to indicate that the loss of water through defective plumbing, including leaky ball cocks and various other similar appurtenances, amounted to about 15 per cent. of the total supply. This latter estimate, however, is approximate and may be either too large or too small for the city as a whole. Again, not only these investigations but also the great extent of excavations made by the Rapid Transit Railroad Commission show that the loss of water directly from the pipes and mains of the distributing system is not nearly so much as has been thought; indeed, they show that it is comparatively small.

A careful consideration of all these facts indicates clearly that the aggregate of all the sources of preventable waste in the city is much more likely to be small than large.

It appears to be reasonable to take from 60 to 75 gal. per head of population per day as the average purely domestic use, with plumbing in reasonably good condition. If there be added to this the quantity of water legitimately used for all other purposes such as power, street flushing, fire purposes and water front consumption, it will be found that the difference between that total and the average consumption for the entire city of about 120 gal. per head of population per day is not large. There is no reason to believe that if every available and effective means for reducing the waste of water, such as universal metering and continual inspection, were installed under the most favoring conditions, that a reduction of as much as 15 per cent. of the average present daily consumption could be attained within three to four years. Furthermore it is the universal experience with public water supplies that what may be termed the legitimate use of water is constantly increasing. It is about as certain as anything of such a nature can be that the reduction of consumption under the circumstances described above would no more than meet this legitimate enhanced annual demand by water consumers.

It is full time that this subject of water waste be treated rationally and not after the manner of speculative and irresponsible though well-meaning reformers in the use of water. The erroneous views in regard to this question of water waste held by even intelligent people are well illustrated by an incident which took place in one of the recent public hearings before the New York State Water Commission at Kingston. A prominent counsel for one of the opponents of the proposed plan of additional water supply from the Catskill regions, opening the report of the former Commission on Additional Water Supply at one of the tables in the back of the volume, asserted that the table before him showed a waste of water in the City of New York of fully three-fourths of the total supply. Although cautioned that he might be in error he positively and triumphantly asserted the correctness of his position and cited the table to support him. One of the attending engineers for the New York Board of Water Supply immediately showed him,

however, that what he positively asserted to be the waste of the city was simply the unmetered portion of the total supply. Most of the criticisms of the proposed present plan based upon the supposed great preventable waste are equally unfounded and absurd.

The total consumption of water in New York City, i. e., about 120 gal. per head of population per day, is moderate when it is remembered that the City of Boston consumes 140 gal., Baltimore 120 gal., Cleveland 145 gal., St. Louis 135 gal., Philadelphia 230 gal., and Buffalo 325 gal. in 1902. These figures show that it is dangerously illusory to expect any sensible relief by the reduction of preventable waste. The City of New York needs much more quickly than it can be obtained the additional water which the Board of Water Supply is now endeavoring to secure from the Catskill regions. In all probability the city will experience a severe water famine before the Catskill water can give it relief even under the most favoring conditions.

### Electrolysis in Pittsburg.

Some weeks ago the daily papers printed despatches from Pittsburg to the effect that an electric survey of the underground metallic structures of the city revealed considerable damage to the steelwork in the foundations of important buildings. It was said the report on the survey was suppressed on account of the serious nature of its revelations of damage by wandering return currents. A copy of it has recently been shown to The Engineering Record, but no such dire news of definite trouble can be found in it. The nearest approach to the newspaper rumor which it presents is the following glittering generality: "Incidentally, in making electrolytic surveys, the care and preservation of substructures constructed of steel have been repeatedly called to my attention, for in these days of progression, where steel is used in enormous amounts underground, we have little knowledge whether electrolysis is seriously at work or not. Both grounded lighting and electric street railway ground currents may be seriously injuring these great underground substructures, in which case a very small current of electricity steadily at work for a number of years might do a great amount of damage before it was detected. The damage to underground steel structures of buildings is very difficult to discover on account of the inaccessibility of the substructure, but it would seem that this is most certainly a very grave possibility, with results too awful to foretell. It may be after a great calamity or the rebuilding of some of the earlier structures that some very valuable data will be obtained therefrom."

While the report thus fails to come up to the newspaper statements it is decidedly interesting from other points of view. It was made by Mr. E. E. Brownell, B.E.E., who states that "as a prelude and to properly introduce the subject of electrolytic deterioration of subsurface metallic structures as thoroughly as the merits of the case should warrant, it is deemed necessary to qualify and establish the true practical theory before submitting any conditions." The author then proceeds to wrap up most of what he has to say in poorly associated selections from the unabridged dictionary. "The zenith of a man's glory is attained," he asserts, "when he has mastered and reached the highest state of the art in whatever scientific field that he may be developing or establishing the laws which govern it." This sounds as imposing as a Fourth of July oration on Bingville Common, but just what relation it bears to electrolysis in Pittsburg is not evident. Nor is it clear what reason exists for informing the Pittsburg Department of Public Works, in a technical report, that "no engineer

who has the proper conception of true engineering principles will ever deviate from or forsake the facts of the case in order that his client may triumph over an ill-gotten victory." These quotations indicate the diffuse looseness of language characterizing the report, and indicate how the Associated Press may have been deluded into the belief that there was something important in the document.

There are places in the report which indicate that the author is writing a book rather than a report to a municipal officer; the following sentence is an example: "After persistent solicitations on the part of many of my clients, I have yielded to their requests, and shall endeavor to embody in this volume my years of experience in a general summary." Spurred on by these persistent solicitations of his clients, of whom a partial list is given in another part of the report, the author delves deep into the theory of the subject and brings to light new discoveries whose strangeness is equalled only by the strangeness of the language describing them. "All kinds of soil and earth formations," he says, "withhold the different electrolytes in mechanical suspense, the water or moisture in the soil retaining them in chemical solution to a more or less degree." Such examples could be repeated from almost every page, but it is unnecessary to do so, for the character of the definite results of the Pittsburg investigation can be readily made clear in another way. These results are stated as follows: "The sum of the current leaving the surface of the distributing water lines was found to be a total of 4,040 amperes, which amount of current, according to the law of electro-chemical equivalents, means that the electrolytic depreciation upon the water system is about 80,800 lb. of iron per year." This precise statement is based on measurements of "the difference in electrical pressure and the standard earth resistance between the pipes and the rails," and then calculating by Ohm's law the current flowing through the earth between the pipes and the rails. An ampere-year is assumed to remove 20 lb. of iron from a pipe negative to the rail. This estimate depends for its validity on the reliability of the figures of the resistance between the pipes and rails, and unfortunately very little reliance can be placed in them. Earth measurement was made by extending a lead from a micro-ohmmeter to the rail and another to a good contact as near the main as possible. This method is too uncertain to be worth much. The resistance measured in this way may be affected by the passage of a sprinkling cart some distance away, by leakage from sewers and water pipes in the vicinity and by other causes which render the numerical result a matter of chance. Consequently, the statement that 80,800 lb. of iron are being taken annually from the water mains of Pittsburg is as unreliable as a similar statement made in St. Louis some months ago and completely disproved there.

Electrolysis is a very serious subject in many cities, and Mr. Brownell does well to "earnestly suggest that the earliest possible co-operative measures be adopted" by the railway officials and the owners of underground metallic structures. Such a plan is followed in Detroit and other cities with satisfactory results. But to burden a report on the subject with a mass of inaccurate generalities and to base very precise statements of injury to pipes on roughly approximate data is to afford the railway companies an opportunity for legitimate ridicule of the technical brief against them. Where it is a matter of the co-operation of such conflicting interests as street railway companies, water departments, and gas and telephone companies, the preparation of reports is a matter calling for tact as well as technical knowledge of electrical conditions.

### The Failure of the Charing Cross Station Roof.

One of the most instructive accidents to engineering structures that have happened lately was the collapse on Dec. 5 of the wind screen and a truss of the Charing Cross trainshed in London. This famous structure, built in 1860 from the designs of the late Sir John Hawkshaw, is doubtless well known to many of the readers of this journal, for it was long considered a model for such buildings. The roof was carried by fourteen trusses and a wind screen, with a clear span of 166 ft. The trusses were 35 ft. apart on centers, and connected by sixteen purlins. Each truss was essentially a plate-girder arch rib stiffened by light bracing, so that the elevation of the truss was crescent-shaped. The rib had a rise of 45 ft. at the center. It was built of an 18-in. web plate  $\frac{1}{2}$  in. thick and four 6x3x $\frac{1}{2}$ -in. flange angles, with their long legs outstanding. At one end, the foot of the rib was connected to a stone cap on top of a pier forming part of the wall of the shed. At the other end there was an expansion joint of the rocker type, the end of the rib being hung by a link from a fixed casting on top of the wall pier.

The bracing of the truss consisted of eight vertical struts, each consisting of two 6x3x $\frac{1}{2}$ -in. T bars, bolted together, and cross-bracing of 4x $\frac{1}{2}$ -in. flats. These members were riveted at the top to the main rib by means of gusset plates, and at the bottom they were riveted to threaded couplings, into which were screwed the rods forming the tie or lower chord of the truss. Each tie rod was made up of nine lengths, from  $4\frac{1}{4}$  to  $4\frac{3}{4}$  in. in diameter originally. According to a statement of the platform inspector at the station, the first indication of trouble on the day of the accident was the sudden breaking of the tie rod of the first truss, next the wind screen, at a point about one-third of the span from one of the walls. The roof gradually sunk at this place and in about fifteen minutes fell away from the wind screen, which fell in less than a minute afterward. In the collapse one of the walls was pushed outward so as to fall on an adjacent building, wrecking it thoroughly.

The trusses were constructed of wrought iron, and it seems not unlikely that the failure of the tie bar was due to a defective weld in it. At the time the roof was built it was impracticable to produce bars of this diameter and some 20 ft. length, in a single piece. This is shown by some statements made by Sir Henry Bessemer in 1856, only four years before the construction of the trainshed. "It is true that hitherto no better method has been known than the puddling process, in which from 4 to 5 cwt. of iron is all that can be operated on at a time, and even this small quantity is divided into homeopathic doses of some 70 to 80 lb., each of which is moulded and fashioned by human labor, carefully watched and tended in the furnace, and removed therefrom, one at a time, to be carefully manipulated and squeezed into form." The tie bars of this roof must have weighed about 1,000 tons apiece, and it is evident that they could result only from welding together a number of short sections. That process, in bars over 4 in. in diameter, was a trying task, even to the best workmen.

It is accordingly of deep interest to know what was the condition of the ends of the fractured bar. They have been examined by a contributor to "The Builder," from whose valuable report the following statement is taken verbatim: "In the area of 15.9 sq. in. [of the broken bar] there are three portions with a lustrous fracture. Two of these are disposed symmetrically on either side of the vertical axis, the base of the segment in each case being at an angle of about 40 deg. with

the same axis, and extending from the top to a little below the center. The third portion indicating recent rupture is of smaller area, and the base of this segment is perpendicular to the vertical axis, the distance from the chord to the circumference of the circle being about one-sixth of the diameter. The collective area of the three portions of the section representing sound metal is barely 6 sq. in. Inside these three areas there is a portion roughly of triangular form, the surface of the metal being corroded, and having very much the appearance of a defective weld, and in the middle of the triangle is a darker area, where the metal is not only seriously corroded, but presents small cavities. Viewed from the side the broken end of the bar has a uniform inclination of about 45 deg., resembling that of a scarf weld."

While an accident of this character is not to be expected in the tie rods of to-day, made without welds, the same contributor to "The Builder" makes some statements concerning the condition of the ironwork as a whole that are deserving of careful consideration. The corrosion that had taken place on the metal had greatly impaired its strength. The rod that broke showed pitting and scaling a quarter of an inch deep in places. The web of the main rib of the truss, originally half an inch thick, had little more than three-sixteenths of an inch of sound metal left, and several holes had been punched clean through it in the wreckage. The paint could be torn from the fallen members in long strips and in many places showed rust on the side next to the iron. This is a condition that deserves the attention of all engineers who have charge of old structures exposed to moist and smoky air. The failure of the roof was not due to any defect in the design, although its details would be changed if it were to be rebuilt, but rather to defects in workmanship which have become a thing of the past owing to the introduction of steel. The interest in the accident lies in the fact that the tie rod held together so long as it did under the corroding influences which destroyed more than half of the web of the main rib. The lesson of the collapse is manifestly the necessity of protecting such structures from rust.

### Heavy Electric Traction.

For some time the electrical and street railway journals have received a large amount of instructive reading matter from engineers interested in heavy electric traction. It has rarely happened that the relative merits of different systems of traction were so vigorously presented in the technical press as of late. The first gun in the public controversy was fired by one of the members of the Electric Traction Commission of the New York Central lines, who assailed the decision of the New York, New Haven & Hartford R. R. to operate its trains into the Grand Central Station in New York by alternating-current locomotives. The New York Central electrical equipment was designed for direct-current operation, and this critic claimed that the use of alternating equipment was undesirable for several reasons. In the first place, the upper floor of the new station is intended exclusively for express trains hauled by electric locomotives, and not for suburban trains. The plans of the New Haven company are assumed to contemplate running its suburban trains into this part of the station, for, it is asserted, locomotive-hauled trains cannot be handled on the sharp curves of the lower floor, which is intended by the Central's engineers for multiple-unit suburban trains. There were also claims made in this initial correspondence that the power service over the Central's lines would be complicated unduly by

the use of alternating-current apparatus by the New Haven road. While the Central officials did not make any public statement concerning the matter, it was evident that the determination of the New Haven company to use alternating-current motors was not at all acceptable to them, and probably the public utterances of the member of their technical committee reflected in a large measure their own opinions.

The matter drifted along for a time without any important comment in print, the few statements by the officials of the New Haven road being characterized by failure to convey any information of actual importance concerning the reasons for their decision. Meanwhile, however, Mr. George Westinghouse circulated privately copies of correspondence he had conducted with the New York Central authorities regarding the merits of alternating-current motors for heavy electric traction. These letters were finally published in the "Street Railway Journal," and have produced so much controversy in the columns of that paper that the average railway officer, intrusted with the duty of selecting equipment to replace locomotives on any portion of his lines, must wonder whether it is not good policy to stick to steam for a time, until the situation clears up. As the correspondence grew in volume others were drawn into it who had no part in the original epistolary combat, and even the General Electric Co., which never talks for publication concerning subjects of serious controversy, has been compelled to break its rule and make the following statement: "The General Electric Co. is in the business of manufacturing electric apparatus, and is prepared to furnish alternating or direct-current systems as may be suitable. It has perfected what it believes to be the best alternating-current railway system in the world, and wherever the circumstances make the use of such a system desirable, it recommends its adoption in preference to the direct system. The company does not, however, endeavor to force either system on the customer irrespective of the best engineering practice with reference to the special conditions under which the system is to be operated."

This letter puts the situation in a nutshell. The General Electric Co. designed the type of apparatus adopted by the Central authorities for their New York terminal, while the Westinghouse Co. designed the different type for the New Haven people for much the same class of service. One of the members of the Technical Commission of the Central road apparently fears that any difference from the decision of that commission is a reflection on the professional ability of its members. As a matter of fact, the choice between direct and alternating-current equipment hangs on matters of such slight importance in many cases that personal preference is a perfectly sound ground for reaching a decision. In other cases the alternating-current equipment is manifestly best, and in still others the direct-current equipment. At the present stage of the art there is not much definitely known on the subject except what is carefully treasured by the great rival manufacturing companies. One of them leans toward direct current and the other toward alternating current. Probably both are entirely justified in holding these preferences by the facts known to them. It is certain, however, that in a little while, when railways of both types are in operation, that the public at large will have abundant opportunity to ascertain more about the apparatus than either company knows at the present time, for no matter how good a guide theory may be, the test of practical operation is the only safe reliance of the railway officer.

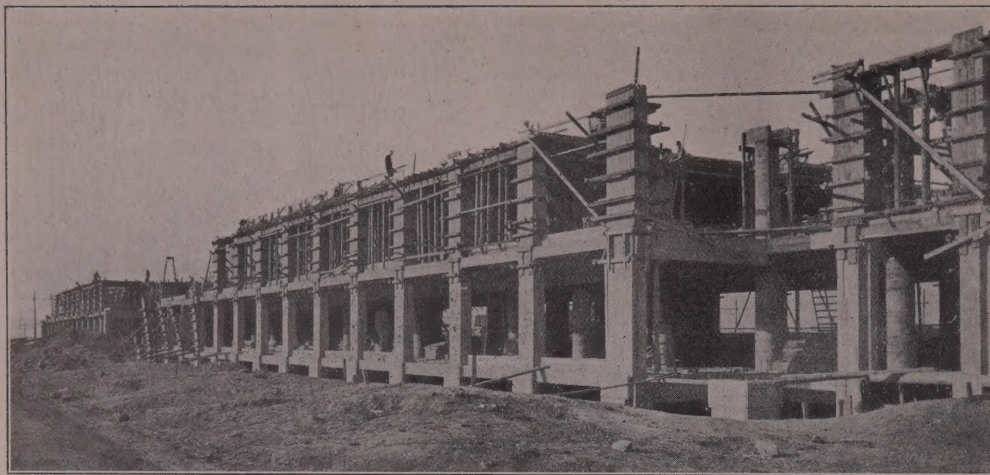
The New York Central authorities have shown a degree of caution and ability in reaching their decision to employ direct-current apparatus that

merits the highest approval by the public. The New Haven people have preferred to accept the guaranty of one of the most successful engineers and manufacturers in the world, who has about him a technical staff of great ability; this gentleman is willing to supply all kinds of bonds that his equipment will be satisfactory. It must be said, however, that the action of the New Haven road in departing from the plans of the Central road in operating trains into and from the new terminal, provided any such departure is really contemplated, is not at all conducive to harmony and mutual assistance, which are particularly desirable in railway circles now. So far as the selection of the different equipment is concerned, however, it is difficult to see the reason for all the fireworks that have been shot off. From a public point of view it is a very desirable thing to have two great companies striving to introduce different kinds of apparatus; it is by such competition that progress is attained. There will always be differences of opinion concerning the value of electrical equipment, just as there are about horses. The fact that these differences are just now over very important apparatus makes it unfortunate that the real points to be considered are befuddled by a lot of side issues, which only concern the accuracy of judgment of a single individual on a single problem.

### Notes and Comments.

IMPROVEMENTS IN THREAD ROLLING MACHINERY have been incorporated in a machine which has been perfected by a leading machine tool builder. A radical departure from former methods is the use of circular dies for the rolling process instead of reciprocating flat dies. One of the dies is a massive semi-circular stationary block, inside of which a small circular die revolves. The construction of the machine is such that the tremendously heavy rolling pressures are possible without affecting the necessarily delicate adjustments of alignment of the thread contours upon the die blocks. The great advantage of rolled threads on bolts of all sizes over the usual process of cutting, due to retaining the skin metal of the bolt body, has been amply proved, especially for places where corrosion is encountered as in boiler staybolts.

A HAZARD TO LIFE which results from the growth of large cities and has attracted but little attention is the insecure character of temporary structures. Street spectacles in large cities often attract great numbers of people who require to be accommodated with seats or standing room on temporary structures used but once and hence cheaply constructed. A carpenter is, therefore, generally intrusted with the entire job and without competent supervision. The structure of light timber scantling with slight bracing is considered fit for surging crowds frequently moving quickly from one part to another. Such duties are the most severe and trying to which any structure can be subjected, and the natural result of inadequate provision for them is disaster. The safety of hundreds of lives depends upon the proper design of these street stands or platforms, and as it is an extremely simple matter to make them safe there is no reason whatever why they should not be so. It is absolutely necessary, however, that they should be constructed under competent engineering supervision. If a municipal corporation does not afford an officer qualified for such a supervision the service of a competent consulting engineer should be engaged to insure the safe design and construction of the work. The fact that these structures are temporary does not in itself diminish the hazard to the people who intrust themselves to them, but indirectly increases it enormously.



View of Factory Building during Erection.

### THE REINFORCED CONCRETE FACTORIES FOR THE BUSH TERMINAL.

The Bush Terminal is a large receiving, storage and shipping plant on the shore of New York Bay, in the southern part of the borough of Brooklyn. The company owns about 160 acres of land with about 3,500 ft. of water front and about 25,000 lin. ft. of bulkhead and pier front; occupying nearly all of the area between Second and Third Avenues and 28th and 37th Sts., and the area between Second Ave. and the water front and from 39th St. to 52d St. On these sites there are already built and in service five piers and pier sheds each 1,300 ft. long and 150 ft. wide with docks 270 ft. wide and 40 ft. deep between them, which enable the largest steamers to lie side by side in the dock and be loaded or unloaded while leaving room for other ships to pass in or out of the dock between them. Another duplicate pier is now under construction and a seventh pier is proposed. The piers are of pile construction with solid earth filling and their sheds are of steel as described in *The Engineering Record* of Oct. 28, 1905. They are well equipped with hoisting and transporting facilities, electric light and automatic fire service.

Adjacent to the piers there are twenty-four 50x150-ft. eight-story warehouses, twelve of which are of mill construction with thick plank roofs, and twelve of open joist construction with 1-in. pine roof boards. Eight more are now being built of mill construction and thirteen of reinforced concrete construction. There is also a large group of isolated one-story brick buildings exclusively for the storage of cotton and other fibre and additions to both classes of buildings are planned and constructed as needed. The land and improvements for this enterprise have an estimated value of about \$10,000,000 of which about \$7,500,000 have been expended since construction was commenced in 1902. The buildings and piers are connected by a complete system of about 20 miles of standard gauge R. R. tracks for freight and passenger service, and are equipped with numerous large freight elevators, electric portable hoisting apparatus, electric lights, water and automatic fire protection. These advantages greatly reduce the cost of handling, storing and distributing freight, and provision is made for the trans-shipping, forwarding and storage of all kinds of merchandise by the Terminal Company without farther attention by their customers who simply receive and deliver it at their own warehouses. These facilities have attracted a number of important steamship lines which have rented the piers and the terminal has handled about 400,000 tons of merchandise during the year 1905.

In connection with this warehouse and shipping business the Terminal Company has planned a system of factories which they intend to build and own and rent for manufacturing purposes. These will have all the advantages of the terminal facilities and the Terminal Company will receive and deliver their goods without trouble for their tenants. It is planned to erect 18 large fireproof factories on a portion of the Terminal Company's land. Very careful studies were made of the most desirable types of construction and that of reinforced concrete with special details for floors and columns was adopted. The plans for the first factory were completed in 1904. The construction for the first building was commenced in December of that year, and the concrete portion of it was completed in December, 1905.

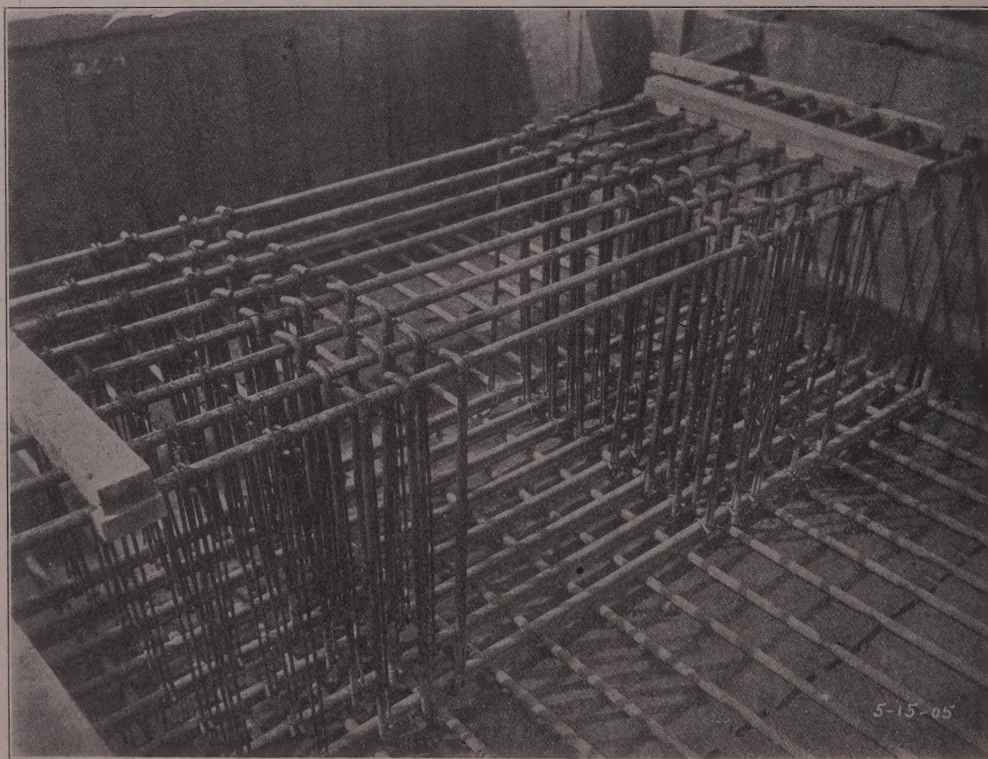
The general system has been developed by Mr. Irving T. Bush, president of the Bush Terminal Co., and constructed under the direction of E. P. Goodrich, chief engineer. Mr. R. T. Tucker is consulting engineer for the factory, and Mr. William Higginson, consulting architect. The

exterior elevations were designed by Kirby, Petit & Green, architects, and the reinforced concrete details have been worked out and their construction supervised under direction of the chief engineer, by Bertine & Son.

The building is 600 ft. long, 75 ft. wide and 113 ft. high from cellar floor to top of parapet. It has six stories and a basement and contains about 12,000 cubic yd. of concrete and 2,000,000 lb. of steel and will cost with its equipment about \$450,000. The site is about 500 ft. from the shore line at a level about 5 ft. above high water. The soil was all made ground, and was excavated to a depth of about 8 ft. over the entire area. The foundations are all made with piles, of which there were about 3,000 driven to a depth of about 18 ft. and calculated to sustain loads of 40,000 lb. each. The earth was excavated 3 ft. below ground water level and about 1 ft. below the tops of the piles and the concrete footings were built in the sheeted pits enclosing the pile tops. The piles are located about 3 ft. apart in two rows 32 in. apart under each of the main side walls. At the ends of the building the side walls are heavier and the footings have three rows of piles. At the center of the building there is a special foundation platform which covers the entire width of the building for a distance of about 42 ft. and is supported on fourteen transverse rows of piles. The columns have separate rectangular footings each of them supported on 18 piles.

A large portion of the exterior walls of the building is glazed so that the concrete piers between the vertical rows of windows virtually become rectangular wall columns 16½ ft. apart on centers. These columns are in transverse rows each having 3 interior columns. They are also arranged in three longitudinal rows, one row on the center line of the building and one row 17 ft. 8 in. each side of it, thus leaving an outside space of 20 ft. between the last row of columns and the exterior of the wall piers. At each end of the building there is a special arrangement of a few more columns, making a total of 114 interior columns.

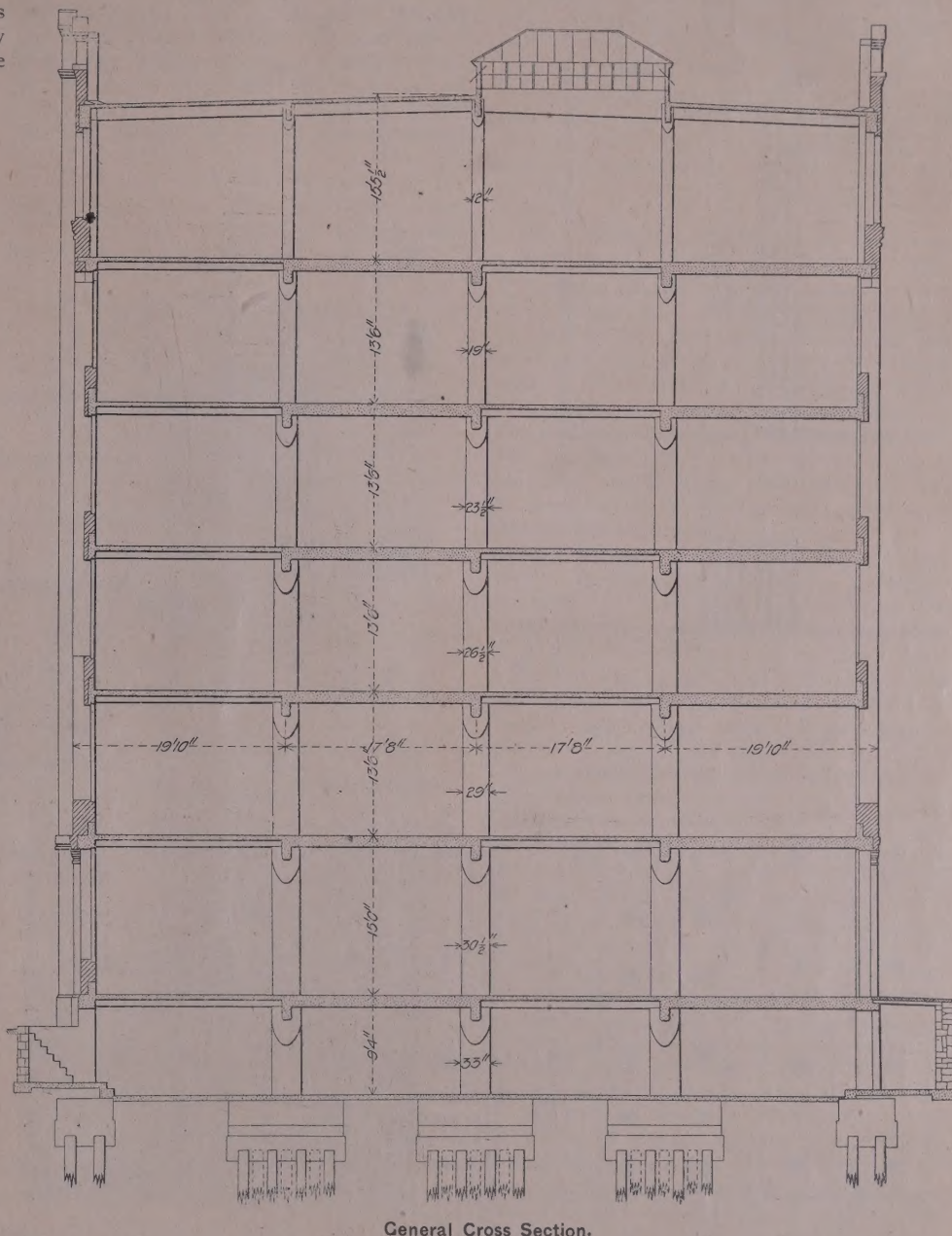
The columns are connected longitudinally by massive reinforced concrete girders which divide



Reinforcement for Wall Column Footing.

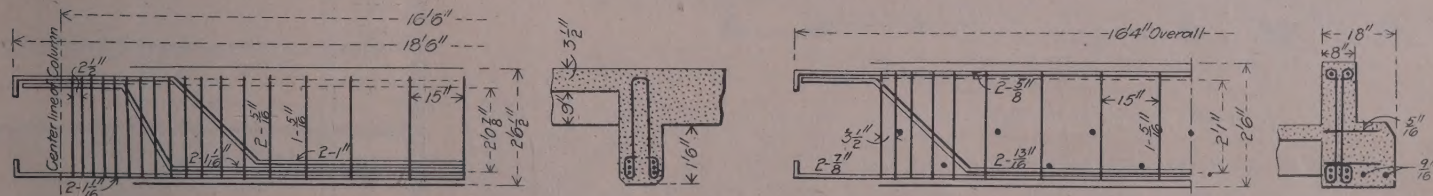
In the main portion of the building the floors in these longitudinal panels are carried entirely by the longitudinal girders without any transverse

have a course of concrete 27½ in. thick, 11 ft. wide and 12 ft. 4 in. long which extends to a depth of 12 in. below the tops of the 18 foundation piles. It is reinforced by a single layer of 1 in. rods 24 in. apart near the upper surface. On it is built a second course of concrete acting as an extended base to distribute the column load equally over the entire footing. It is 30½



### Regular Interior Column.

### General Cross Section.



Regular Interior Longitudinal Girder; Longitudinal Wall Girder.

of reinforced concrete 3½ in. thick supported on the reinforced concrete longitudinal girders and on similar transverse girders at columns and immediately. The interior columns are solid concrete cylinders fireproofed by annular concrete shells. The exterior walls are of brick work supported at each story by reinforced concrete girders which with the interior girders are made integral with the floor slabs and bonded to them with reinforced bars.

in. deep in the center and 12 in. deep on both edges, and is reinforced by 8 transverse sets of 1 in. steel bars fastened together with vertical members to make the reinforcement trusses characteristic of this system. There are also 1 in. transverse horizontal bars  $6\frac{3}{4}$  in. apart close to the lower surface of the concrete as shown in the detail of a typical column footing. In the center of the footing four vertical bars 1 in. in diameter and  $4\frac{1}{2}$  ft. in length are bedded in the footing and extend 27 in. above its upper surface.



as to form a rigid truss-like skeleton that is placed complete in the beam-mould and has sufficient strength to maintain its shape while being handled and while the concrete is placed around it, thus insuring its accurate location in the finished girders, a feature which is considered of special importance in this system of construction.

In the center of the building, where only a 200-lb. live load is provided for, the floors are not of the corrugated type but are made with solid slabs of uniform thickness supported on both longitudinal and transverse girders similar to the one described. The slabs are 4 and 5 in. thick and are nearly square with maximum spans of about 14 ft. The reinforcement consists of  $\frac{1}{2}$ -in. round longitudinal and transverse bars about 6 or 7 in. apart in each direction. The regular girders for the side walls have an L-shape cross section and are reinforced by 6 main rods from  $\frac{5}{8}$  to  $\frac{7}{8}$  in. in diameter as indicated in the detail sections. The lateral extension of the girder is reinforced by horizontal transverse bars and supports the window sills and a belt course on the exterior of the wall.

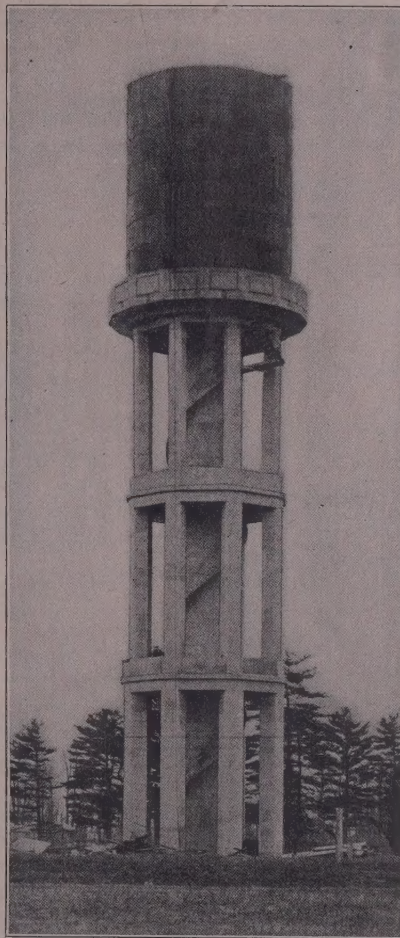
All concrete except for the foundations, where Giant Portland cement is used, is made 1:2:4 with Atlas Portland cement and washed gravel or broken stone which will pass through  $\frac{3}{4}$ -in. mesh and will be rejected by a  $\frac{1}{4}$ -in. mesh. In the columns  $1\frac{1}{2}$ -in. broken stone is added to the gravel and the cinder concrete in the shell is made 1:3:6. The quality of the cement is maintained equal to the standard specifications by mill inspection and by frequent tests. Test cubes 4x4 in. are made from the concrete every third day and give high ultimate compressive strength when 28 days old. The concrete was mixed wet in Ransome machines and each floor was allowed to set at least 6 days before the supports for it were removed. The whole of the building is already under lease to tenants taking from 8,000 to several hundred thousand square ft. each of floor surface. The character of the finished construction is such that some of the tenants rely solely on it and on the automatic sprinkler service for fire protection and do not carry fire insurance. The strength and rigidity are such that one tenant will install seven drop hammers on the fifth floor, another will have concentrated loads of over 1,000 lb. per square ft. on large areas of the fourth floor and another will have two-story tanks resting on the first floor without extra basement supports.

The Turner Construction Co. supplied the labor and superintendence for the concrete work and Mr. De F. H. Dixon, the secretary of that company, superintended the execution of the work. Steel was purchased chiefly from the Carnegie Steel Co., Giant cement was purchased from the United Building Material Co., gravel and Cowboy sand from the Phoenix Towing Co. Mr. Chas. Hart was the contractor for excavation. Mr. J. D. Walsh was the contractor for the pile driving, and Messrs. Ficklin & Stobaugh were the contractors for the footings and cellar floor. The Raab Iron Works was the contractor for bending and wiring the reinforcement rods for the beams and girders. Atlas cement tests were made at the site by a representative of the Pittsburg Testing Laboratory, which also tested the Giant cement at the mills. All materials were purchased by the Bush Terminal Co.

A FOUR-CYLINDER SIMPLE LOCOMOTIVE is an innovation which is being tried on the London & Southwestern Ry. in England. The arrangement of cylinders conforms with that of the De Glehn compound, two being outside-connected to the middle pair of driving wheels and the other two inside connected to a cranked axle of the forward pair of drivers.

## Reinforced-Concrete Water Tower at Bordentown, N. J.

The water works system of Bordentown, N. J., which was formerly owned by a private company, that supplied water from the Delaware River, has recently been purchased and completely remodeled by the city. The river has been abandoned as a source of supply and a pumping station erected in connection with a system of infiltration collector pipes, 3 miles inland, on the bank of a small tidal stream, an arm of the Delaware River. Pumps in this station elevate the water supplied by the collectors through a 10-in. riser main, 3.3 miles long, to a 200,000-gal. steel tank on a reinforced-concrete tower on a hill above the town. The distribution system is under direct pressure from this tank, the average pressure in the town being 60 lb.



The Bordentown Tower.

The infiltration collectors are built along the base of a bluff composed of sand and gravel and underlaid by a stratum of clay. This stratum of clay rises on a slight slope as it leaves the creek valley and comes to the surface several miles inland. The water from the overlying gravels flows into the creek through a number of springs, and the ground in the vicinity of the station is completely saturated. The infiltration collectors connect with a concrete suction well for the pumps in the station building. They consist of vitrified sewer pipe, laid with open joints in trenches partially filled with various sizes of screened gravel and then covered with clay puddle. A 12-in. main collector extends along the base of the hill each way from the pumping station, the total length of the two branches being 1,200 ft. One of these main collectors has an 8-in. lateral branch, 250 ft. long, laid up the valley of a small brook which

heads in the hill. The other has three 8-in. lateral branches, with a total length of 800 ft., which tap springs in the hillside. An 8-in. collector, 400 ft. long is also laid up a ravine adjacent to the station and connects directly with the suction well. Where the collectors come in contact with clay their pipes are laid with cement joints to prevent the entrance of muddy water. The supply afforded by the collectors is ample, and could be greatly increased by extending them. A 6-in. well, 125 ft. deep, has been sunk in the bottom of the suction well, however, to insure a supply if for any reason the water from the collectors is shut off. This well penetrated the thick stratum of clay under the gravel and entered a second stratum of water-bearing gravel in which the water is under considerable pressure.

The concrete suction well is 30 ft. in diameter and 34.5 ft. deep. It has 20-in. walls and a floor of concrete, 4 ft. thick. Owing to the saturation of the ground much difficulty was experienced in its construction. The original plan was to build it with an open bottom and to allow the ground water to enter. Much of the layer of clay underlying the upper water-bearing stratum had to be excavated to construct it, however, and as it was considered dangerous to risk the liability of the water from the second water-bearing stratum breaking through and undermining the walls, the concrete bottom was laid.

The pumping station is a 26.5x53.5-ft., one-story brick building. It is divided in an 18x26.5-ft. pump room and a 24x32-ft. boiler room. The floor of the pump room is depressed 10 ft. to form a pit in which the pumps are placed. Owing to the ground water reaching nearly to the top of this pit during floods it was built of concrete and its sides and bottom heavily reinforced. A vertical compound, duplex, Worthington pump and a horizontal compound, duplex, Deane pump elevate the water from the suction well against a head of 200 ft. to the steel tank on the reinforced-concrete tower. Steam is supplied by two horizontal return tubular boilers in the boiler room. A radial brick stack, 75 ft. high, furnishes draft for the boiler furnaces.

The details of the plans for the reinforced-concrete tower on which the steel tank stands were described in *The Engineering Record*, Oct. 1, 1904. These plans have been generally followed as outlined at that time, but a number of important details have been changed. The tower is 100 ft. high from the top of its footing course to the floor on which the tank stands. It is formed by 8 vertical columns spaced equally around the circumference of a 26.5-ft. circle, and a hollow concrete cylinder, 8 ft. in diameter, built concentric with the circle on which the columns are spaced, and joined to them by the floors of three balconies. These balconies are 33 ft. 4 in. apart, and divided the tower in three sections, although the concrete in the columns, cylinder and floors was laid monolithic from the footing to the top of the tower.

The concrete footing on which the tank rests is a 16-sided polygon in plan. It is 6 ft. thick, 38 ft. in diameter at the bottom and 32 ft. in diameter at the top. The columns are 3.5 ft. square up to the first balcony, 3 ft. square from the first to the second and 2.5 ft. square from the second to the top balcony. The inner side of each column is in the same vertical plane from the bottom to the top, the reduction in size being made by stepping the other three sides at the balconies. Each column is reinforced by 4 plain round rods, one near each corner. These rods vary from  $1\frac{3}{8}$  in. in diameter between the second and top balconies to  $1\frac{1}{8}$  in. in diameter between the footing and the first balcony. Horizontal tie rods,  $\frac{1}{4}$  in. in diameter, are placed on 12-in. centers around the vertical rods. The

latter were provided chiefly to take compression and are imbedded 12 in. in the concrete footing. Their bottoms rest on special cast-iron bases, 12 in. in diameter, the details of which are shown in an accompanying illustration. The bottom of each rod is in a 2-in. pipe sleeve, 1.5 ft. long, which also rests on the cast-iron base. The central cylinder is provided to reduce the load on the columns and the span of the floor system at the same time giving additional resistance to the flexure in the structure due to wind pressure. It has also been made to serve as a protection to the supply and overflow pipes for the elevated tank. It has 18-in. walls up to the first balcony, 15-in. walls between the first and second balconies and 12-in. walls from the latter to the top. It is reinforced with 1-in. vertical rods to the first balcony and with  $\frac{7}{8}$ -in. rods from there to the top. Horizontal  $\frac{1}{4}$ -in. tie rods are placed on 12-in. centers around the vertical rods. The supply and overflow pipes for the tank are both 10-in. wrought-iron. They are supported by flanges in the bottom of the tank and by a special support at the first and second balconies. Each of these supports consists of two 9-in., 15-lb. channels with their ends embedded in the concrete of the central cylinder. One channel is placed on each side of the pipes and the latter are hung from them by hangers which allow for expansion and contraction.

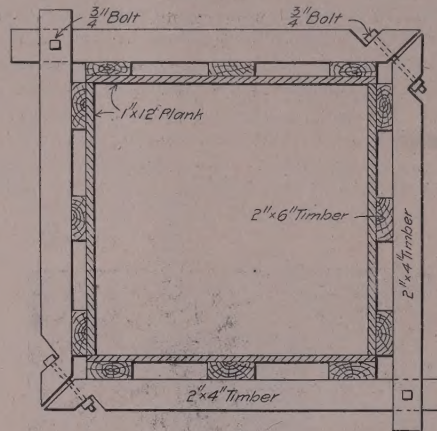
The details of the columns, central cylinder and floor at the first balcony are shown in one of the accompanying illustrations. The floor is reinforced with  $\frac{1}{2}$ -in. Johnson bars, radiating from the center, and is built monolithic with the central cylinder and the columns. It is also carried at the outer edge by 2x3.5-ft. beams extending from column to column. A concrete railing, 6 in. thick and 3 ft. high, surrounds the balcony. The general arrangement and the details of the second balcony floor are practically the same as those of the first. The floor of the third balcony carries the tank, and is 36.5 ft. in diameter and 16 in. thick. The radial reinforcing rods in it are 1 in. It cantilevers 4.5 ft. over the columns and the beams between them, and its section in this cantilever is proportioned to the moment. A 4-ft. balustrade is placed around this balcony. A reinforced-concrete spiral stairway extends from the footing to the top of the tower, between the central cylinder and the columns, and is carried by the footing and the floors of the balconies. The reinforced-concrete stairway was built at about one-third the cost of an iron stairway and little difficulty was experienced in erecting it.

The 200,000-gal. steel tank on top of the tower is 30 ft. in diameter and 40 ft. high. It is built of standard boiler plate steel in 5-ft. sections. A flat roof of  $\frac{7}{8}$ -in. sheeting is provided to protect the water from sunlight and flying debris. This roof is supported around the edge on the periphery of the tank and at the center on the 10-in. wrought-iron overflow pipe.

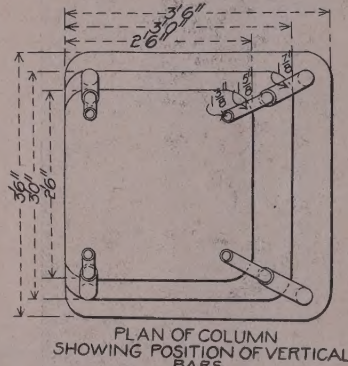
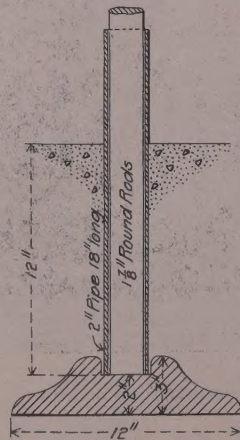
The improved appearance of the reinforced-concrete tower as compared with an ordinary steel tower was given more consideration in selecting the former than the difference in cost between the two types of construction. Proposals were invited, however, for both types and out of 11 bids offered, one was the same for both, four favored in price the concrete tower and in the other six the price for the steel tower was lower. The contract price for the reinforced-concrete tower was \$10,500, complete.

The original intention was to employ broken stone for ballast in the concrete. A good quality of gravel was obtainable, however, and was used instead. The concrete for the footing was mixed in the proportions of 1 part of cement, 3 of sand and 5 of gravel; that in the tower in the proportions of 1 of cement, 2 of sand and 4 of

gravel. Alpha Portland cement was used throughout. The general design of the tower was made so the forming for the concrete would be as simple as possible, as well as to produce a pleasing effect. The nature of the structure required specially well-built forms, nevertheless, and a number of intricate construction details, such as the spiral stairway, were unavoidably included. Several methods of building forms were developed during the construction, which



Clamp for Column Forms.

PLAN OF COLUMN  
SHOWING POSITION OF VERTICAL  
BARS

BASE FOR COLUMN RODS

Details of Reinforced-Concrete Tower, Bordentown Water Works.

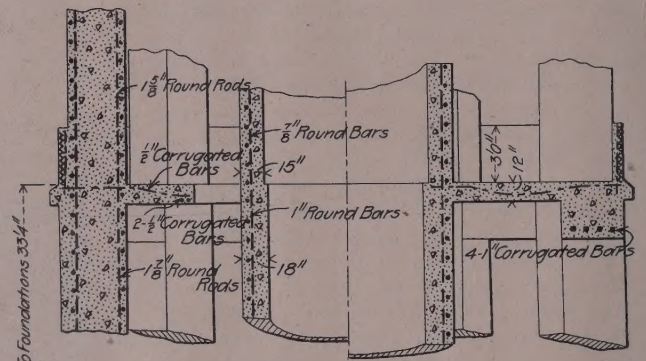
greatly simplified the latter and reduced the cost of lumber, without detracting from the appearance or injuring the quality of the finished concrete.

The interior of the central cylinder was not required to have a finished appearance, and the forms for it consisted of  $\frac{1}{2}$ -in. flooring, placed vertically and braced from the inside. A finish was required on the exterior of the cylinder and the forms for it were made of  $\frac{1}{2}$ -in. flooring nailed to carefully cut transverse templates. These forms were built in sections 6 ft. long and with a width equal to  $\frac{1}{16}$  of the circumference of the outside of the cylinder. A template was placed at each end and at the middle of each section. After the cylinder was started the alternate sections of the forms were placed

3 ft. above those between them, breaking joints 3 ft. The sections were held in place by  $\frac{1}{2}$ x2-in. iron bands on about 3-ft. centers, the breaking of joints in the segmental forms always affording a blocking of the concrete already laid to hold the sections in place. The reinforcing rods were temporarily held in place by being attached to templates nailed to the inner forms.

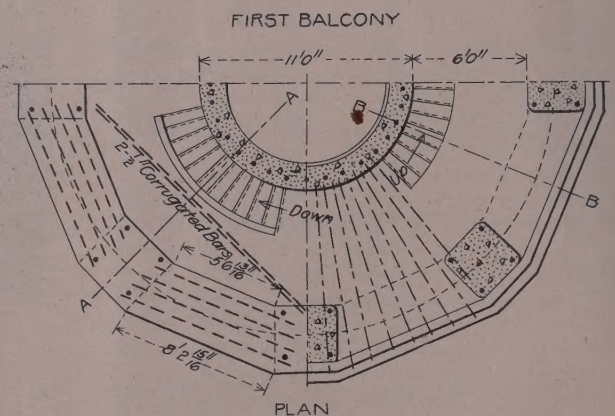
The forms for the columns were made of dressed 1-in. boards, placed horizontally. Those for each side of a column were nailed to three 2x10-in. vertical pieces in 12-ft. lengths. The four sides of the form for each column were not nailed together, but were held in place by clamps, the details of which are shown in one of the illustrations. These clamps were placed about 3 ft. apart, with their mitered joints at alternating corners. They were found to be very efficient, no staging being required to hold them in place and the lines of the finished concrete being perfectly true. They also made it possible to take the sections of the forms down easily and use them in the work above.

A Carlin hoist elevator was placed in a timber framework shaft at one side of the tower. Plank runways were laid, leading in from the shaft, one at every 6-ft. level, beginning at the bottom. The concrete was mixed by hand and loaded into two-wheeled Ransome buggies, which were raised by



SECTION A-A

SECTION B-B



FIRST BALCONY

PLAN

the elevator to the level of the work. The concrete in central cylinder and the columns was thus carried up at the same rate. The forms for the beams and floor of the first balcony were supported on timber scaffolding built up from the footing. When this balcony was completed the forms for the portion of the central cylinder and the columns between it and the second balcony were built up on it, the lumber used in erecting the tower up to this height being used again. The forms for the upper third of the tower were built up from the second balcony in the same manner, the portions of the tower between the balconies thus being built independently.

The concrete was made quite wet and carefully tamped in place with flat tools, in order to work

the stones well back from the surface. No plastering was done and the appearance of the concrete as it came from the forms may be seen in the view of the finished tower.

The plans for the improvements to the water works system and for the reinforced-concrete tower were made by Mr. C. C. Vermeule, of New York City, and the construction was carried on under his supervision. Mr. Hugh J. Reilly, Jr., of New York City, was the contractor for all of the work. Mr. J. B. McBride had immediate direction of the work for Mr. Vermuelle.

### Water Triangulation.

Water triangulation, so-called, was an interesting expedient adopted by Mr. E. E. Haskell in a hydrographic survey under the general direction of Major Lansing H. Beach, Corps of Engineers, U. S. A. To start these surveys from the primary triangulation of the Lake Survey would have been quite expensive, so Mr. F. G. Ray conceived the idea of using the foremast of the survey steamer, provided with a collapsible balloon-rigged signal, for a triangulation station. Starting with a tertiary line located nearly

### Water Hazards of New York City.

That the water supply of a city of 4,000,000 people should be so administered that, in a year of slightly more than average rainfall, the quantity of water in December remaining in the impounding reservoirs upon which the 2,400,000 inhabitants of two boroughs are absolutely dependent should be reduced to less than 50 days' supply, with the natural flow of the river only about one-half the daily consumption, will at once strike a competent water-works engineer as a hazardous state of affairs. This condition of the reservoirs is pictorially shown by diagram No. 1, which, as one engineer remarked, makes a man thirsty who looks at it. When certain additional facts are presented, an engineer's fears will scarcely be allayed. The natural flow of the river upon which, with its tributaries, the impounding reservoirs are situated has, during the thirty-eight years for which records have been kept, for five years in the month of December and for four years in the month of January, been less than half the present rate of consumption, now more than 300,000,000 gal. daily. Since records have been kept, the natural flow of the river in one or the other of these two months has four

fail to be uncomfortably suggestive to the veriest layman. It shows the great discrepancy between the total safe yield of all the sources of supply of the whole city and the rate of consumption during recent years. In days of old such recklessness would have been regarded as a tempting of Providence. And this disaster-inviting policy actually went to the bitter limit in 1891, when, about the middle of November, the supply of water in the impounding reservoirs was entirely exhausted. All the available water in the distributing reservoirs within the city was then equivalent to only about one day's supply, and so within two days the city would have had nothing but the natural flow of the river, which was then only 50,000,000 gal. daily, while the usual rate of consumption was 140,000,000 gal. At this juncture a rain, which might well be called providential, occurred, breaking the drought, and with succeeding rains, replenished the reservoirs.

Successive years of plentiful rainfall, with the help of new reservoirs completed from time to time, maintained a comfortable supply of water, concealing the real risk which the city was running. Meanwhile the construction of the greatest impounding reservoir of the system was dragging slowly along, delayed by many difficulties of one kind and another. It was amid these conditions that, in October, 1903, Mr. J. Waldo Smith was appointed chief engineer of the Aqueduct Commissioners. Realizing at once the imminent possibility of the recurrence of the perils of 1891, if the rainfall should drop below the average for a year or two, he promptly made vigorous efforts to rush the New Croton reservoir to completion, and with it the large storage and distributing reservoir under construction at Jerome Park, in the city. In these endeavors the chief engineer was heartily supported by the contractors.

Some of the physical difficulties attending the completion of the new Croton dam have been described by articles appearing at various times in this journal, but there have been other difficulties which cannot be published at this time. Somewhat novel methods of construction were introduced, and at times the work was prosecuted by night as well as by day. Masonry was laid in a narrowly restricted space at an unprecedented rate. New equipment was provided by the contractors to meet the emergency. By thus vigorously pushing all along the line the reservoir was sufficiently near to completion by the beginning of January, 1905, to permit the impounding in it of a large quantity of water which would otherwise have flowed past the city's works. In addition to the unavailable water required to fill the lower part of the basin, approximately forty days' supply was saved, which was later completely drawn out for the city's consumption.

Had it not been for this succor, New York would have been alarmingly close to a grave shortage of water during the month just past, as will be readily perceived by referring to the first part of this article and making a simple subtraction. The foregoing statements are the most emphatic possible comment on the value to the city of the water made available by the energetic work of the preceding year. Not only has the critical period of 1905 been safely passed, but sufficient reservoir capacity has been added to the system to provide with reasonable security for at least one more year. The New Croton reservoir is now completed, but entirely empty. If there be sufficient precipitation during the early months of 1906 to fill it, together with all the other Croton reservoirs, which are so nearly empty, the boroughs of Manhattan and the Bronx will have a reasonably plentiful supply of water for the coming year; but, in spite of the new reservoir, a season of low rainfall would be cause for apprehension. Furthermore, just so much more margin of safety has been put between the city and

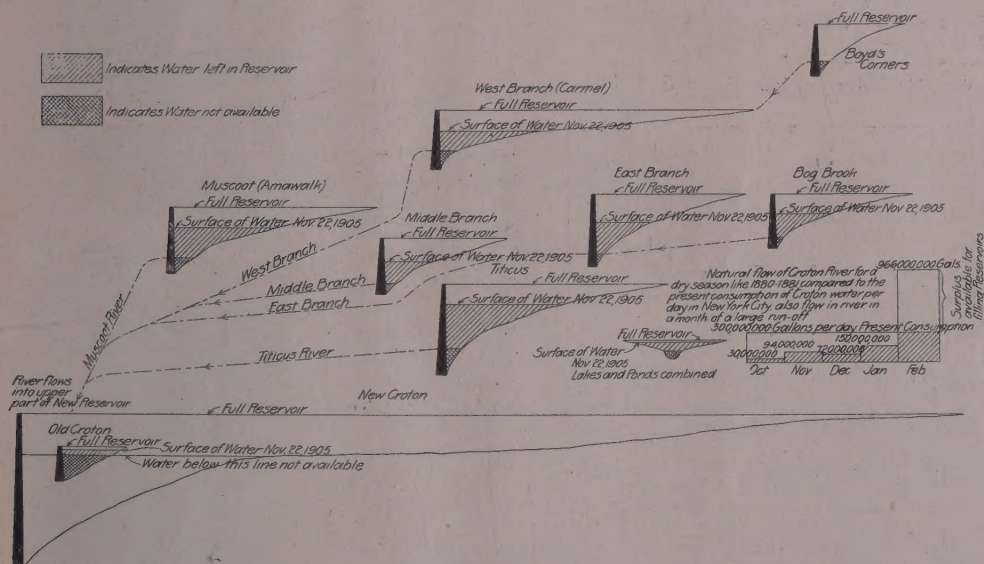


Diagram 1.—Actual Condition of Impounding Reservoirs, Croton Watershed.

a couple of years before, the steamer was anchored about 5 miles offshore, so as to form well-conditioned triangles with the two known stations and a third one selected on shore. The steamer was then located by simultaneous pointings to the balloon signal on foremast from the three stations, and angles read to the adjacent stations. Each observation thus made gave a pair of triangles and one determination of the required length of a new line. Twenty sets of observations were made at intervals of four minutes for a complete determination of the new line, the usual methods of observing angles being employed. An independent set of angles was read to transfer the azimuth. Three such transfers were included in the system besides 13 regular triangles. The closing error was about 1:105,000.

A MEANS OF GREATER ECONOMY for the gas engine lies in the use of weaker combustible mixtures, according to "Gas Power." The greater volumes of air of such mixtures may absorb the excess heat of combustion and give it off in the form of mechanical work. A reason that explosion temperatures and pressures fall so short of what they should be lies, it is said, in the rapidity with which the mixture parts with its heat, so that large amounts appear instantaneously in the water jacket or cooling flanges and are wasted.

times been less than 100,000,000 gal. daily, and the minimum recorded in these months was 71,000,000 gal. in December, 1876. Many times in other months, however, especially in the fall, the flow has been much less, frequently very much less, and in September, 1881, the loss from the reservoirs due to evaporation and other causes, exceeded the natural flow of the river by 10,000,000 gal. daily. In this year of grace the city may get through the winter with just a close call. But what prediction is to be made for next fall and winter in view of the possibility of less than average rainfall during the next few months and a dry summer?

If the natural total flow of the river at the lowest dam be plotted it will at once be impressively evident that a cycle of eighteen years of large flow was preceded by an equal cycle of low flow, and that several of the most recent years have had phenomenally large flows. Is it unreasonable, then, to expect some dry years in the very near future? With these facts one must also study diagram 2, showing the increase of population and the more rapid increase of consumption of water, which latter for the past ten years has averaged for the two boroughs under consideration alone, nearly 15,000,000 gal. daily per year.

The third diagram is, if possible, still more eloquent to the water-works engineer, and can hardly

severe shortages of water which are very likely to occur before any new source of supply can be made available. Hence the importance of having

recently undertaken will increase the quantity which can be safely drawn in dry cycles by only about 25,000,000 gal. daily. New York is at least

some of the most eminent water-works engineers and the technical press.

New York is now seeking authority to obtain an additional supply of water from the Catskill Mountain region. About a year ago a bill was introduced into the Legislature to authorize the city to secure the much-needed water. This bill was passed only after much discussion, and did not become a law until June 3, 1905, when another bill creating a State Water Supply Commission also became law. The second bill, which was numbered just ahead of the New York City bill, requires that all municipal projects for new water supplies shall be passed upon by the State commission. On June 9, Mayor McClellan appointed a Board of Water Supply, which, after effecting a sufficient partial organization, presented a scheme for additional supply to the city government, on Oct. 9. Application was made to the State commission on Nov. 3. Public hearings are now being held, and at the present rate of progress may defer the final action of the State commission until well into the spring. Daily newspaper reports of these hearings for the most part have been quite misleading. There is but little real opposition among the people to be actually affected by the execution of the proposed works; the noise which has had so large space in some press articles has issued principally from a few lawyers who apparently are seeking to establish a basis for future business when settlements for properties and damages are in order. The city's case has been ably conducted by the corporation counsel and the engineers of the Board of Water Supply.

Final locations of the proposed works cannot be made in the field nor contracts for construction prepared until the decision of the State Water Supply Commission shall have been handed down. Even if the decision be favorable, a year will be necessary to prepare for actual construction on a large scale. Meanwhile such preliminary operations as can be carried on are being pushed unrelentingly under the able direction of Mr. J. Waldo Smith, who became chief engineer of the Board of Water Supply on Aug. 1. With the most

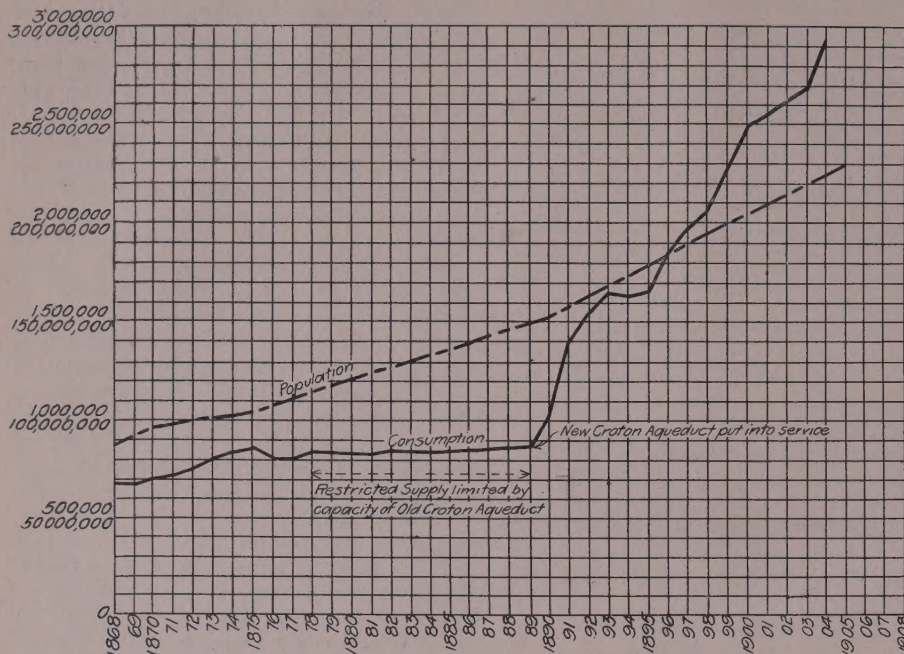


Diagram 2. Population and Water Consumption, Manhattan and the Bronx.

this basin ready at this time to husband as much water as is feasible cannot be overstated.

In years of average rainfall or more, some water would still flow to waste over the spillway of the lowest dam. Therefore, to aid in spanning the dangerous gap of five or six years which, at the best, must elapse before any water from a new source of supply can be made available, Mr. Smith urged the construction of two more reservoirs on tributaries of the Croton, Cross River reservoir of 9,000,000,000 gal. and Croton Falls reservoir of 16,000,000,000 gal. available capacity. The completion of these reservoirs has been most unfortunately delayed by a taxpayer's suit attacking the legality of the contract for the Cross River reservoir. The supreme court of New York finally decided on Nov. 14 that the contract was legal, establishing the right of the Aqueduct Commissioners to award a contract to another than the lowest bidder and to make contracts for engineering work at unit prices, although the quantities given as a basis for the canvassing of the bids were only estimated by the engineer with such degree of accuracy as the data made possible, and, hence the total obligation of the city under the contract not absolutely determined. On account of this delay it is not now expected that the Cross River reservoir can be ready for impounding water before January, 1908, and Croton Falls reservoir not before January, 1909.

What may happen to the city's water supply from the Croton watershed during the years of waiting for the new water, in the event of a repetition of the stream-flow conditions of the years from 1879 to 1887 is suggested by diagram 4. If, however, rains are more plentiful and more fortunately distributed, the two new reservoirs may be of very great value. Cross River and Croton Falls reservoirs will carry the storage development of the watershed somewhat beyond the economical limit, as determined by such a series of dry years as has occurred since records have been kept, but their potential value in reducing the scarcity of water pending the relief from a new source quite warrants the expenditure necessary for their construction. The safe yield of the watershed with the existing reservoirs has already been exceeded by the average consumption for the year just closed to the extent of about 30,000,000 gal. daily. The two reservoirs

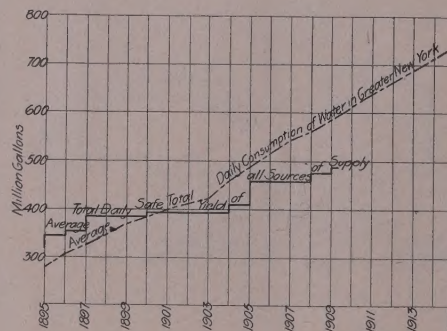


Diagram 3. Consumption and Certain Supply.

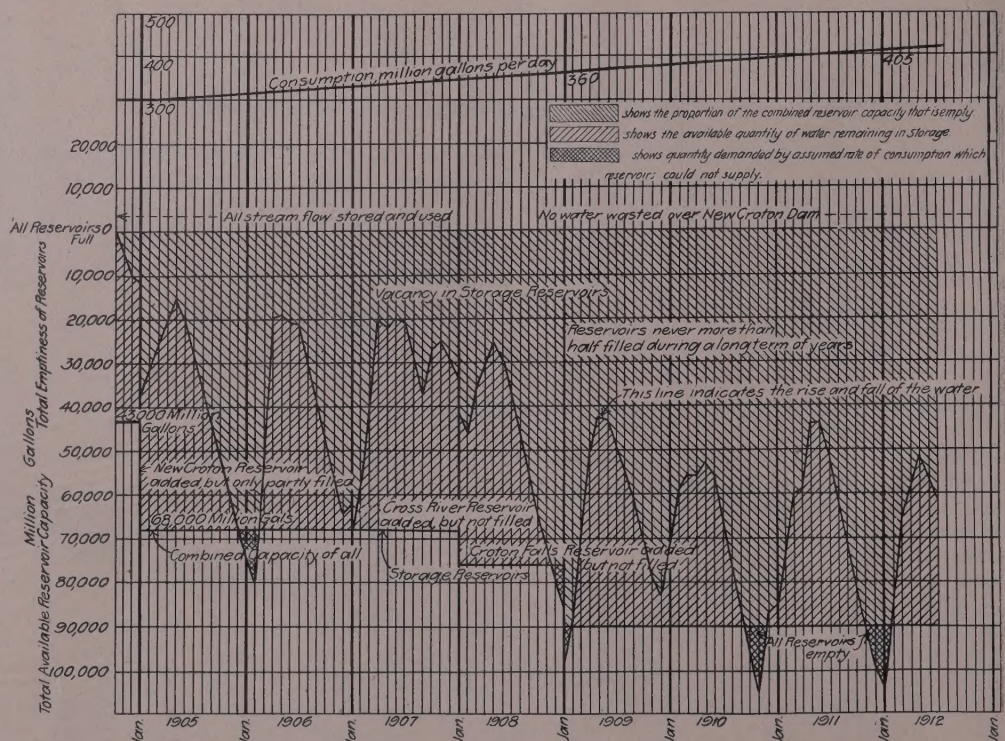


Diagram 4. Water Consumption, Depletion of Reservoirs and Total Reservoir Capacity.

five years behind its needs in providing itself with water, and this in disregard of the most urgent recommendations, frequently reiterated, of

rapid progress which can reasonably be anticipated, at least five years, it is estimated, must elapse before water from Esopus Creek, the near-

est of the new sources, can be made partially available by building the portion of the Catskill aqueduct between the proposed great Ashokan reservoir and the Croton watershed. This reservoir, too, will have to be partially constructed within this time. Since the Old and New Croton aqueducts have a combined capacity approximately 100,000,000 gal. daily in excess of the safe yield of the Croton River in dry years, this quantity could be added to the low service supply of the city while the Catskill works are being completed to deliver 500,000,000 gal. daily at approximately 150 ft. greater elevation. The Catskill works were fully described in the Current News Supplement of this journal for Oct. 14, 1905.

Severe criticism has many times been passed upon the department and commission which have hitherto managed New York's water works for permitting the city to run such hazards as were described above, and some of this criticism has probably been well deserved. The project for the Catskill additional supply has been entrusted to a board composed of business men instead of

### Erecting Temporary Trestles.

A boom mounted on an axle carried by four flanged wheels has been employed by H. S. Kerbaugh, Inc., of Philadelphia, Pa., in erecting temporary trestles used in making railroad and other embankments. The trestles built by this contractor are generally made stronger than the usual run of such structures in order to insure safety to the workmen and the plant on them. Each bent is capped with a 12x12-in. timber and the ties for the track are laid on two 12x12-in. stringers, one under each rail. The general arrangement of the erector may be seen in the accompanying illustration. The four wheels carrying the boom are set in pairs, one pair toward each end of the axle. The two wheels of each pair are placed back to back so their flanges come against the sides of one stringer; those of the other pair of wheels bear against the sides of the other stringer. A 20-ft. boom is pivoted 4.5 ft. from one of its ends between the pairs of wheels on the common axle.



View of Boom Derrick Used in Erecting Temporary Trestles

politicians. An excellent beginning has been made in organizing a force independently of political influence. For the good of the city, it is to be hoped that the high standards of these early days will be courageously maintained. It will be well for the Board of Water Supply and its engineers to remember that the eyes of the world will frequently be turned upon so gigantic a municipal undertaking.

THE IMPORTANT POSITION held by the American Railway Engineering and Maintenance of Way Association is shown by the fact that of the total 207,977 miles of single-track mileage in the country, using the Interstate Commerce Commissioner's 1904 figures, 170,883 miles or 82 per cent. have representatives in the society. Railways in Canada, Mexico, Central and South America, Japan, India, Australia, New Zealand and Russia are also represented. Most of the officials who belong to the association hold the rank of chief engineer, of which grade there are 94, but there are also 49 engineers of maintenance of way, 53 assistant engineers, 30 division engineers, 28 superintendents, 21 general managers, 14 presidents, 17 vice-presidents and many other ranks is somewhat smaller numbers.

The erector works from the end of the trestle already erected, the wheels running on the stringers. The short end of the boom is anchored to the trestle by a 1x4-in. strip of iron, 4 ft. long, swung from its center in a stirrup on the end of a threaded iron rod which extends up through a block on the boom. A hand nut on the rod above the block permits the strip of iron to be drawn up against the under side of the stringers, when placed transversely to them, pulling the short end of the boom down and anchoring it securely. A block and fall is suspended from the outer end of the boom and is rove with a rope which passes through a sheave built in the outer end of the boom and then through one in the short end. A team attached to this rope is used in hoisting the bents and stringers. A trestle bent and the two stringers extending from it to the next bent in the rear are erected at each set up of the boom. The latter is very readily moved forward, the anchor bar being swung parallel with the stringers by loosening the hand nut until the bar is free.

An erector of this type was used in the construction of five miles of trestle required in making a fill on the new low-grade line of the Pennsylvania R. R., described in The Engineering Record Dec.

16, 1905, and in erecting a much larger amount of trestle required in the construction of the Enola yard connected with the same work. It is possible to reduce the trestle erecting crew from 14 men required without the erector to eight men necessary when it is employed, and at the same time the erection work may be carried on with greater rapidity.

### Experiments with Superheated Steam.

The Bavarian Revisions-Verein has lately made a large number of experiments with superheated steam to determine the effect of pressure, jacketing, intermediate superheating and number of cylinders. The full data are not yet worked out, but preliminary statements concerning them by Mr. C. Berner in the "Zeitschrift" of the Society of German Engineers give the following information:

As regards the transmission of heat through conducting surfaces, with steam velocities from 15 to 100 m.-sec. no noticeable effect on the transmission was observable. The higher velocity only produces a greater loss of pressure; thus the resistance to flow in a coiled superheater tube is at least 20 per cent. greater than in a smooth pipe.

A peculiarity which had previously been observed, the great increase of heat transmission with increase of load on the superheater, was again noticed. This increase is usually attributed to the influence of the velocity of the flue gases and of the steam; but this view is not tenable. Only the dependence on the temperature gradient remains. This latter is, in many cases, of by far the most importance, the effect of velocity being generally negligible. In the transmission of superheated steam the tests have shown that Péclet's results, instead of being 25 per cent. too small, are in reality 70 to 80 per cent. too low. As regards the specific of superheated steam, Linde's results have been confirmed, so that Lorenz' equation gives mean results at least 20 to 25 per cent. too high.

According to the height of the steam temperature the pipe-wall temperature can lie either above or below the saturation temperature of the steam. It was found that condensation increases rapidly from the instant the pipe-wall temperature falls below the saturation temperature, but no condensation can take place if the wall is above this temperature. The limiting temperature depends on the pressure and the heat insulation. All experiments have shown that the only determining factor for the heat loss is the temperature gradient between steam and air, the loss not increasing proportionately with, but faster than, the gradient. The absolute value of the temperature of the steam is immaterial. From this it follows that the heat loss must always be greater with superheated than with saturated steam of the same pressure. The influence of uncovered parts in the piping is shown to be very great. The resistance to flow of the steam in pipes with different pressures and velocities is found to be practically the same for both saturated and superheated steam.

CEMENT MORTAR CASINGS are now used on the wharf piles of the Los Angeles division of the Atchison, Topeka & Santa Fé Ry. to prevent injury by limnoria, teredo and similar mollusks. According to Mr. J. F. Parker, the casing is 2 to 2½ in. thick and is carried up from the mud to the high water line. It costs \$1.10 per foot. The mixture is 1 part Gillingham Portland cement to 2 parts fine sand, made up with sea water. It is placed in position by divers with the help of sheet steel molds, made in 3-ft. lengths. After the cement has set for about 6 days the casings are taken off.

### The Turbines in the New Power Station at Sewalls Falls.

The improvements of the power plant of the Concord Electric Co., at Sewalls Falls, N. H., were described at length in this journal on Jan. 6, by Mr. Edw. B. Richardson. In that article he mentioned the general features of the two turbines designed and built specially for the new station by the Allis-Chalmers Co., which has furnished the following additional information concerning the installation. Ordinarily the stream produces a fall which gives a net working head of 16 ft. In times of flood, however, the water backs up in the lower channel so as to reduce the working head to 12 ft. To secure the desired results the Allis-Chalmers Co. has designed the turbines, each with three sets of runners and gates complete, the three sets being arranged one above the other on a vertical shaft.

The three sets of runners are all connected to the tail race by means of draft tubes, as illustrated in the article referred to, so as to derive the full energy of the water, due to its actual head, from each of the runners, no matter what its relative or actual position may be upon the shaft. The lower runner of each wheel has a draft tube by itself, while a single tube of larger dimensions carries off the discharge water from the two upper runners. The turbines are of the Francis central discharge type. The three runners on each wheel are each of equal size, form and capacity; but they do not all discharge in the same direction. The lower one discharges downward into an individual concrete draft tube.



Shaft and Three Runners of One of the Turbines

The upper runner discharges downward and the middle one upward, both into a separate concrete draft tube which joins the lower one at the bottom of the tail race. The reactions from these two runners practically balance one another, while the reaction from the discharge of the lower runner, being upward, tends to lift a portion of the load on the turbine shaft. This effect is considered negligible in the turbine design, but provision is made for using the pressure due to the head of water to carry a considerable part of the weight of the turbines and the generators at all times. This is done by admitting the water of the flume into a space directly under the second runner of each turbine, where it exerts its pressure upward against a circular plate which forms a revolving piston. The water will carry about one-third the weight of the rotating parts. The other two-thirds is carried by a thrust bearing supported by the turbine castings.

The bearing is made of generous proportions so as to operate safely without oil under pressure for lubrication. The lubrication is, in fact, provided for in an ingenious manner. A well is formed outside the bearing rings and this is filled to a suitable height with oil. The oil flows to the inner part of the bearing through suitable holes, passes through the bearing, guided by proper grooves, and is returned through holes to the well. The circulating action is continuous so long as the wheel is in action, and it is automatic. At

two points below the thrust bearing the shaft is kept in line by steady bearings carried by portions of the wheel casings. The wheel casings are self-supporting besides carrying the weight of the rotating parts, one section being built on top of the other, and each provided with four stout columns to carry the weight. The casings are steadied and held against vibrations and side strains by having certain parts carried over to the walls of the draft tubes. These walls and the draft tubes are of reinforced concrete, and were illustrated in this journal on Jan. 6.

The wheel cases are all divided so as to permit of dismantling without disturbing the shaft or generator parts, and are put together with machined and ground joints.

The shaft itself is in two parts coupled together just below the generator. The runners are of non-corrosive bronze, each cast in one piece. They are 55 in. in diameter. Surrounding each runner are the gates which admit the water to it and control its speed. Outside the gates of each runner, and reaching all around it so as to admit water to all parts of the periphery of the wheel at once, is a space ample for that purpose. The gates are composed of movable guide vanes, so constructed that when open they admit a full head of water with but little interference and when closed totally exclude the water. All are connected by links to a common gate ring and arranged so that a minimum of power is required to operate them.

The operation is through two countershafts standing parallel to the main shaft. These are each provided with a crank at each set of gates, and the cranks are connected to the gate rings

by links. One-eighth of a turn of the shaft completely closes the gates. Not more than 12,000 ft. lbs. is required for this operation. This power is supplied by the governor for each wheel.

The governors are placed on the generator floor beside the generators. They are of the Allis-Chalmers standard type of self-contained oil pressure hydraulic governor. The design is such that no changes in arrangement will need to be made should three or more units be added to the plant. Such additions are not unlikely after two or three years. The permissible variations in speed under sudden variations of load are shown in the following table:

| Variations of load. | Permissible variations in speed. |
|---------------------|----------------------------------|
| 25 per cent. ....   | Not over 2% in 1.5 Sec.          |
| 50 per cent. ....   | Not over 4% in 2 Sec.            |
| 75 per cent. ....   | Not over 6% in 2.5 Sec.          |
| 100 per cent. ....  | Not over 8% in 3 Sec.            |

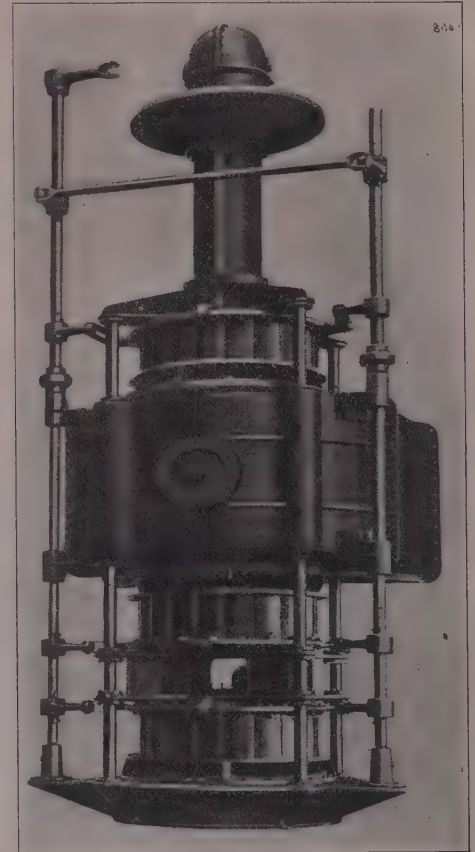
Each governor is driven from a horizontal shaft running under the floor, which takes its motion from the main shaft of the turbine through the medium of a bevel gear.

The bevel wheel on the main shaft is formed by attaching a toothed rim to the outside of the collar of the coupling which joins the two portions of the shaft. A Morse silent chain gear connects the governor to the horizontal shaft and drives the governor. The chain is cased in.

The speed is regulated by sensitive fly balls working against knife edges and the actual con-

trol of the gates is accomplished through the agency of oil under pressure operating through the medium of a piston controlled by a pilot valve. These regulators are so constructed as to eliminate hunting and insure very close regulation. The governors are so arranged that they are under control electrically from the switchboard, and synchronizers and motors for controlling the governors form a part of the outfit of the station. This makes it possible to increase or diminish the speed of either of the wheels at pleasure or to shut down units from the switchboard in case of an emergency.

The wheels will each produce 900 h.-p. with



Turbines for Sewalls Falls Plant.

a 16-ft. head on a consumption of 620 cu. ft. of water per second, or 625 h.-p. at 12-ft. head with a flow of 650 cu. ft. per second. Working at full gate they are expected to economize 78 per cent. of the power of the water, or more, and to give 80 per cent. return at three-fourths gate. At half-gate they are expected to economize 75 per cent. of the power of the water. They operate at 100 revolutions per minute.

Standing directly over the turbines with their stator parts supported on the generator room floor are the two generators, one for each turbine. The rotor shafts are direct-coupled to the shafts of the turbines and form the upper parts of the turbine shafts. The weight of the rotors is carried by the thrust bearings of the turbines; but they have a steady bearing above the coupling to keep them in line. The generators are of the Allis-Chalmers-Bullock vertical water-wheel type.

UNUSUAL FILLING is now being done at Grant Park, Chicago, by the Illinois Tunnel Construction Co., which made an agreement to furnish a million yards of earth to the city without cost. Part of it comes from the new tunnels but the larger portion is furnished by the excavations for foundations for large buildings. This material is delivered through special shafts to the tunnel cars, which run underground to the lake front and then over a viaduct spanning the Illinois Central R. R. to the park.

## The Marion Power Station of the Public Service Corporation of New Jersey.

The engineers of the Public Service Corporation early in its organization, in the summer of 1903, planned for increases in power-station capacity to take care of the ever-increasing business of the company. In the fall of that year a very complete detail report of the future yearly requirements of plant capacity was formulated, with special attention to concentration of power houses. At this time, the Marion plant in Jersey City, the name originating from the nearest Pennsylvania R. R. station, was planned, the necessary appropriation obtained from the Finance Committee, and ground was broken the succeeding spring.

A tract of about fourteen acres in the western portion of Jersey City, on the Hackensack Meadows, was owned by the corporation, lying between the Hackensack River on the west and the N. Y., Susquehanna & Western R. R. (Pennsylvania system) on the east, and the Erie R. R. cuts across the northern corner of the property, within

temporary east end walls of the engine and switchboard buildings are of corrugated iron laid on a light frame work of steel, in order to facilitate future extension in that direction. The engine room walls are lined to a height of about 20 ft. with white enamel brick and for the rest of the height a light buff brick, presenting a pleasing appearance. Of the projected boiler house arrangement two complete sections have been built with a brick wall partition, the others units to be built as needed when the turbine structure is extended eastward.

The foundations of the turbo-generators are worthy of special mention, involving a system of reinforced concrete arches upon piling, permitting a free flow of the river immediately below the turbines. Water is brought in from the river by a series of 36-in. clay pipes, which extend out below the pile dock and turn downward at the edge of the dock, being hung in position by cross beams before the space beneath the dock was filled in; the mouths of the 36-in. inlets are 13 ft. below low-tide level, thus affording an ample supply of water for condensing purposes at all times. These provisions have been initially made for the

backs of one section of boilers. Each of the present two stacks has a height of 225 ft. and is built of yellow brick. The end stack, supplying a single section of boilers, is 19 ft. 4 in. outside and 12 ft. 4 in. inside diameter at the base, and 11 ft. 2 in. outside and 10 ft. inside diameter at the top. The other, located between the two boiler house units, is 22 ft. 2 in. in diameter at the outside and 15 ft. 2 in. inside at the base, the top having a diameter outside of 15 ft. 5 in. and inside of 14 ft. The foundation of each is alike, built of concrete and 37 ft. in diameter.

The boiler equipment consists of fifteen Babcock & Wilcox 600-horse-power boilers, five boilers being in a half section, supplying the smaller stack, and ten boilers in a section for the larger stack. With the single exception of the outer or half-section row, the boilers will all be located back to back, the flues of brick being below the boilers sealed with cement. The flue dampers are iron plates swung on a vertical axis and are at an angle when closed as shown in the illustration. Hand firing has been adopted, McClave grates being used, to the exclusion of mechanical stokers, but provision has been made so that if desired they can be inserted later.

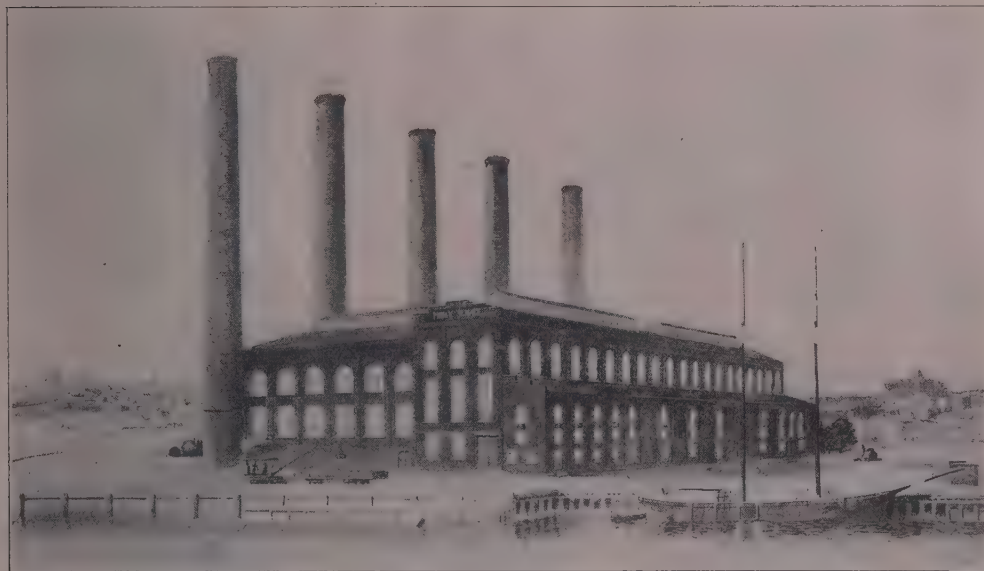
The coal is mechanically handled from the supply pile to the storage pockets over the boiler floor space and is thence delivered to the floor by local coal chutes controlled by the fireman. Below each boiler is a flame plate consisting of a slab of 6-in. reinforced concrete supported at each end on iron girders. Beneath each grate is a steel hopper, lined with concrete, to conduct the ashes to a chute, the opening of which is controlled by gates. Ash cars on standard-gauge tracks receive the ashes direct from the chutes and are used to convey the ashes away from the plant.

The steam piping is carried overhead, suspended from the structural steel frame work, permitting free movement of expansion. The Rockwood type of joint, supplied by M. W. Kellogg & Co., is used, with vulcabeston gaskets on all the 6-in. auxiliary mains and the 10-in. live steam feeder lines. All runs are curved to guard against straining joints. Chapman valves are used on all steam connections, except valves below 4 in., where Hancock globe valves are used. The blow-offs have connections to the feed-water lines for use as an emergency method of feed-water supply to the boilers if necessary. The pipe covering on the superheated lines is 3 in. of 85 per cent. magnesia, laid on in 1½-in. thicknesses plastered with a ¼-in. layer of asbestos compound and then covered with 8-oz. duck sewed on. The other steam piping has sectional covering. The relief valve on the 5,000-kw. exhaust is a 36-in. and on the 3,000-kw. turbine a 30-in. Blake valve.

There are three Warren vertical boiler feed pumps, each with 14x11x12-in. cylinders, which run 50 to 100 strokes per min., and are capable of delivering 980 gal. per min. Each has an 8-in. suction and 7-in. discharge. They are set with their water cylinders below the floor line, giving a head of 5 ft. on the suction valves, which is sufficient to prevent trouble when pumping hot water.

Each turbine unit has an Edward's duplex 12x30x14-in. direct-driven suction valveless air pump, supplied by the Wheeler Condenser & Engineering Co., used as the condenser and air pump. The suction pipe drops directly through the turbine-room floor into the intake canal from the river, the diameter of the suction pipe being 24 in. with a 20-in. delivery.

The exhausts from all of the steam auxiliaries are led to an exhaust main which delivers into the two open feed-water heaters, a divide-box in this main and between the two heaters, permitting adjustment by hand so as to proportion the inlet to each heater, as required. These heaters are the Cochran open heater built by the Harrison



View of Marion Power House.

200 ft. of the station-building. A spur of standard gauge track was laid to connect with the Pennsylvania tracks, the whole length of the plot and into the engine room and beneath the ash chutes of the boilers.

The Hackensack River, within 70 ft. of the buildings, narrows at this point and is about 60 ft. deep, the immediate shore affording a dock depth at low tide of 18 ft. Thus excellent tide-water facilities are afforded for coal delivery, supplemented by the facilities afforded by the railroads mentioned.

A view of the present power-house structures is shown in section, exhibiting the fine tide-water location. A view is also given of the plant as it will appear on the enlargement to 32,000 kilowatt capacity, showing Jersey City in the background. The map of the Northern Jersey electrical distribution system shows clearly the geographically central location of this new power house and its relative position to the present central stations and sub-stations and to the districts to be supplied.

The building is substantial, though severely plain, no attempt being made to gain architectural beauty. The boggy nature of the soil required care in the construction of foundations, which were built on reinforced concrete caps laid upon 3-ft. piling. The walls are of red brick, excepting a temporary wall at the east end of the engine and switchboard building, filling in upon a structural steel frame with trussed lantern story roof; the

inlet supply for the ultimate capacity of the plant to 64,000 kw.

The condenser outflow or discharge canal is carried down river at an angle and away from the intakes. It consists of a 12x12-ft. raceway below grade, built on the sides of sheet piling, on the bottom with concrete, and is planked over on the top. A view is shown of this work during construction.

A view of the skeleton steel frame work of the building is shown from a photograph taken during construction, clearly exhibiting the partly completed boiler installation, which is supported on steel girders and above the level of the turbine room floor.

The turbine room is 43 ft. by 150 ft. in size. The two boiler rooms together occupy a space of 150 ft. by 115 ft., and the switch and cable building is 21 ft. by 150 ft. The switch and cable building is in reality a lean-to against the engine room wall, containing also the engineer's office. An electrically operated crane runs on an elevated track in the turbine room, supported by a girder resting on the structural columns and is capable of lifting 10 tons. As the railroad tracks entered the building, the crane reduced the cost of unloading and handling of material to a minimum.

The circular brick stacks were built by the Custodis Chimney Construction Co.; they are located outside of the boiler house, and each is connected with a brick flue running the length of the

Safety Boiler Works, and each is rated at 6,000-h.-p. capacity; they are both of the horizontal circular type, 15 ft. long and 6 ft. in diameter. A leader is taken from between the stages of the large turbines to supply additional steam to these heaters at about atmospheric pressure, and is run direct to the heater casings. This enables

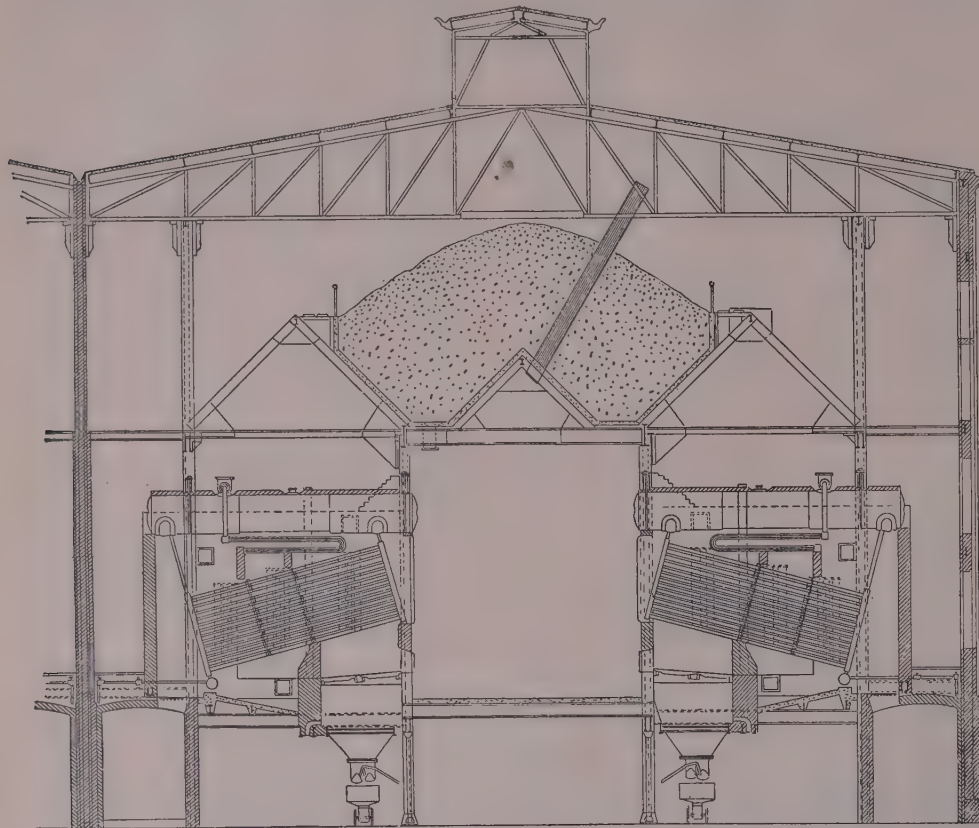
turbine. Both the sensible heat and all of the latent heat is utilized in the heater, while the only further work the steam could do when used expansively in the turbine, is that due to difference of temperature from atmosphere to 28 in. of vacuum. The amount of steam used for this purpose from the turbine will depend, of course, upon

three-phase alternating-current at a potential of 13,200 volts, but the 5,000-kw. units are designed for 25-cycle current for the operation of the railway loads, while the 3,000-kw. unit delivers at 60 cycles, this unit being intended for use upon the lighting systems of the corporation. A unique feature of the turbine equipment is the double condenser arrangement which is used for the 5,000-kw. units. These machines have two Wheeler surface condensers, one of 10,000 sq. ft. upon either side, making 20,000 sq. ft. of condenser surface to each 5,000-kw. unit. The 3,000-kw. turbine has a single Wheeler condenser having 12,000 sq. ft. of surface. An interesting feature is to be noted in the use of the top row of tubes in each condenser as a primary feed-water heater as above referred to.

This station numbers among the first of the large power plants in this country to make use of steam turbine driven auxiliaries. There are two 125-volt exciters, each of 75-kw., direct connected to horizontal Curtis steam turbines, each one being of sufficient capacity for the entire present equipment. Both turbines operate non-condensing, exhausting into the open heaters.

The cables from the generator to the generator busses, the exciter wiring, and the general current controlling wiring and apparatus are shown in the accompanying illustrations. The three conductor cables from the generators are all led in ducts imbedded in the station floor to the basement of the switch building, thence expand along the wall to the respective sectional busses. The systems of busses of flat copper bars are carried in separate compartments in the usual manner, the compartments being of brick construction. From the busses leads are taken to the respective circuit-breaking oil switches, which are the type H-3 of the General Electric Co., throughout.

The instrument panels and operating bench are placed at one end of the present top floor of the switchboard building and on a level with the gal-

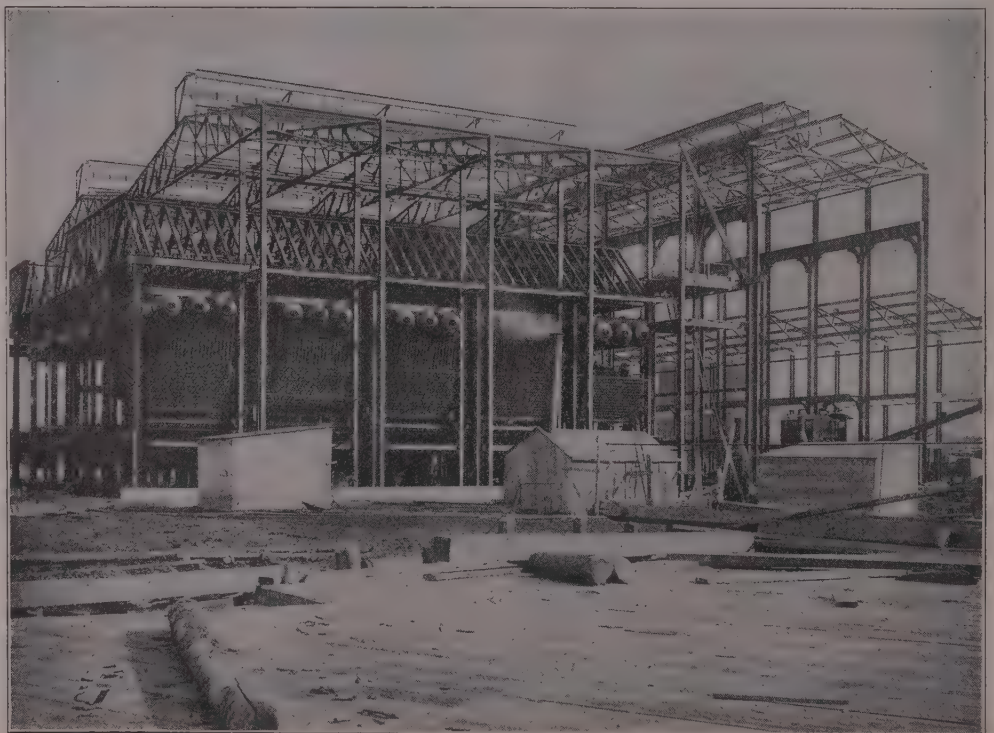


Section of Boiler Room, Showing Coal Pockets.

the temperature of the feed water to be raised up to 210° or 212° F.

The system of feed-water supply involves the following circuit: The Edwards air pump receives the water of condensation from the condensers and returns it to the open heater which acts as a hot well; these heaters are of sufficient capacity to store a 10-minute supply for the boilers. In the delivery from the air pump to the heater it passes through a primary heater formed by the top rows of tubes of the surface condenser; by virtue of their contact with steam entering the condenser, the water is heated to the full temperature of the vacuum. The complete circuit of the water through the plant is therefore from the boilers to the turbines as steam, from the turbines to the condenser, condenser to pump, pump through primary heater, primary heater to the open heater, open heater to the feed pump, and feed pump to the boilers. The entrained air escapes from the discharge of the Edwards air pump through a 12-in. riser carried above the water line. The make-up water is supplied from either the city mains or from a spring water supply on the property.

The auxiliaries in the station are all steam driven and run non-condensing, the exhaust from them being utilized to the fullest extent for heating the feed-water. The amount of such exhaust steam in the turbine plant, however, is not sufficient to raise the temperature of the large amounts of feed used to more than 50 or 60 deg., so provision was made to bring this temperature up as stated by means of the primary heater and steam connection from between stages of the turbines. In addition to the advantage of feeding hot water to the boilers at a constant temperature, there is considerable economy secured by this use of steam after it has done work from boiler pressure to atmospheric pressure in the



Power House under Construction.

the proportions of station load to steam obtained from the auxiliaries, being controlled by a hand valve with a back-pressure valve in the line.

The present turbine equipment consists of two 5,000-kw. and one 3,000-kw. General Electric-Curtis turbo-generators, although provision has been made for an additional 3,000-kw. unit in the present turbine room. All three units deliver

lery, which is on one side and end of the engine room and interconnects the turbines. The operator can thus overlook the generators and face his operating bench at the same moment. The generator supply to each bus is controlled by an oil switch, also with remote control, and which has the auxiliary time limit and reverse-current relays in circuit for protecting the generators and system.

From the bus-bars the current passes to the floor above by separate cables, each being in circuit with an oil switch and connecting to the feeder circuits. Each circuit from a generator has two mains, one of which can be connected to an adjacent sectional bus, which are, however, kept normally closed by clip switches.

The feeder circuits pass downward through ducts to the basement and fan into a series of pull boxes and thence to the cable well and underground conduits, each being protected by Gen-

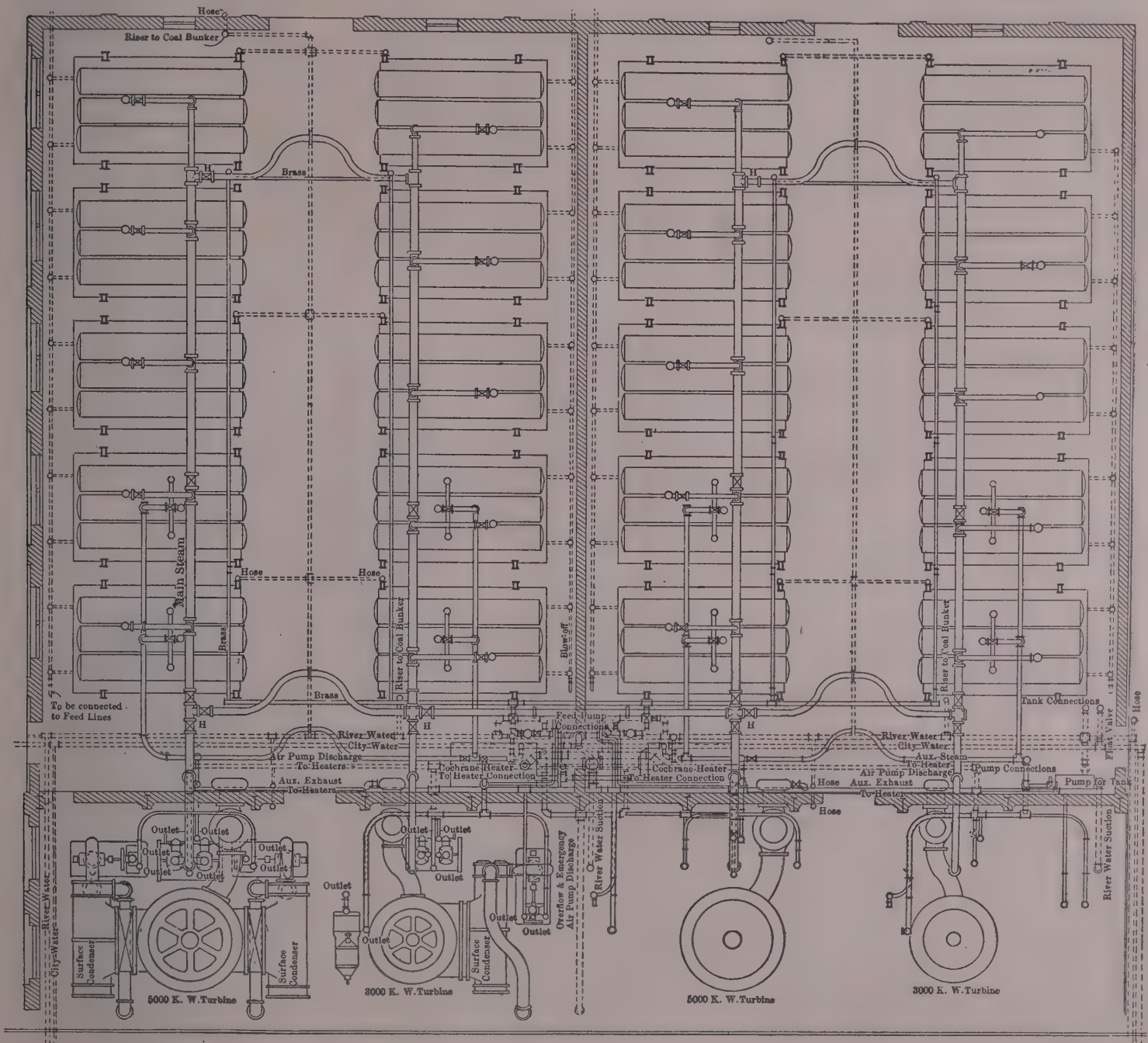
in this case are of rubber core and paper insulation protected by a lead covering. All the current from the exciter sets is brought to the low-tension board on the operating floor and distributed and controlled from there.

A novel feature in the equipment of the switch and cable building is a 100-kw. General Electric motor-generator set consisting of three machines. They embrace first an alternating-current synchronous motor of 600 volts, 25 cycles, supplied by static transformers, stepping down from

to drive the set with 125 volts direct current from an exciter and use either 500 volts direct current or 600 or 13,200 alternating current for testing.

The operation of this station will greatly relieve the heavy demand for energy on the other central stations of the corporation and provide thereby a reserve in case of accident to any of the plants.

Special mention should be made of the courtesy received from Mr. Dudley Farrand, General Man-



Plan of Power House Showing Arrangement of Boilers and Turbines.

eral Electric lightning protectors, which also take care of any unusual rise in voltage.

Current and potential transformers supply the instruments on the panels near the operating board so that only low voltage is in the vicinity of the operator. The current transformers also operate the automatic control of the circuit-breaking switches.

The cables are of rubber insulation, except where they are a continuation into the building from underground to the second floor into cable bells, where each of the three leads are carefully brought away from each other and taped, and the bell filled with insulating compound. The cables

13,200 volts. On the same shaft is a direct-current, 125-volt and a direct-current, 500-volt machine, both interchangeable as motors and generators by the method of switching. The purpose of this special set was to attain any possible desired current for testing work, although additional exciter capacity is also in reserve for the larger generators. It is possible to take trolley current and generate alternating current 600 volts or 13,200 volts for testing, or use 125 volts direct current for exciter current or for lighting the station. Driving by the alternating current end, one can use 500 volts direct current for operating the coal handling or the crane motors. Or it is possible

ager; Mr. James T. Whittlessey, Chief Engineer, and Mr. Vassar, his assistant, for the facilities and information afforded this paper.

A GAS TURBINE has been worked out by Mr. T. G. Saxton, of Lexington, Ky., which embodies a combination of a four-cylinder horizontal gas engine, a small steam boiler fired with oil fuel above the latter, and upon the engine shaft a radial-flow turbine, which is driven by the practically continuous exhausts from the gas engine to which is added steam from the boiler. The outfit runs at 750 r. p. m. and is stated by the "Railway Review" to show promising results.

## Government Contracts: Legal Pitfalls and How to Avoid Them.—V.

By George A. King and William B. King, Members of the Bar of the Court of Claims.

**Delays and Interference.**—Government contractors may be subjected to delays by the action or inaction of government officers. The due performance of their work may be either suspended by official orders or interfered with by improper directions. Such conditions usually cause a loss to the contractor by destroying or lessening the labor value of his employees, by subjecting him to a rise in prices, by consuming time of superintendence, by causing loss of efficiency in plant, or in some other like manner. Nearly all government contracts require the contractor to begin his work promptly, to carry it on diligently and to complete it within a fixed time. The usual provisions authorize the officer in charge to employ additional force in case of unsatisfactory progress, and to annul the contract entirely for continued delays, and they also impose a penalty for failure to complete the work in time. A stringent obligation for promptness is thus enforced upon the contractors.

**The Government Responsible for Delays.**—The courts imply in every contract, in the absence of express stipulation on the subject, an obligation

resulted in a loss of \$5,000 to the contractor. The opinion of Chief Justice Waite in the Supreme Court laid down some important principles, saying:

"There was no time specified within which the work must be done, neither was there any power reserved by the United States to direct its suspension. Under such circumstances, the law implies that the work should be done within a reasonable time, and that the United States would not unnecessarily interfere to prevent this."

"Here the work was stopped by order of the United States. Smith asked to be released from his contract, unless he could go on. This was refused until the expiration of sixty days, when he was allowed to resume. As between individuals, certainly, this would be considered an improper interference, and damages would be awarded to the extent of the loss which was the necessary consequence of the suspension. The United States must answer according to the same rule."

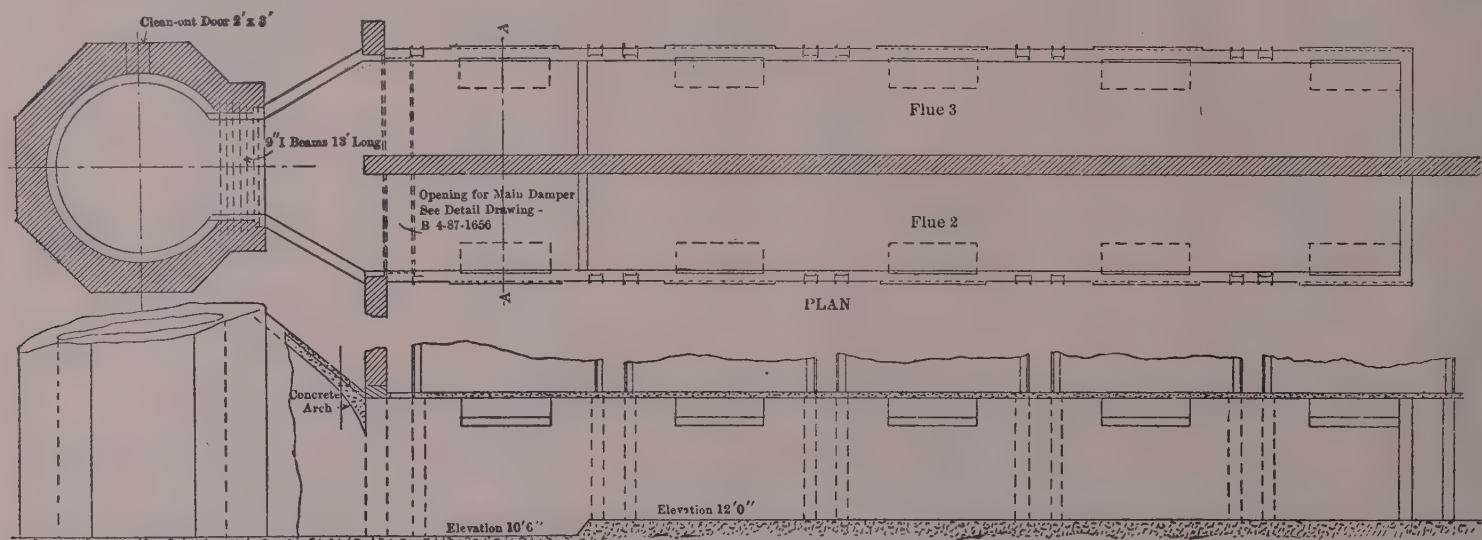
"The United States can be required to make compensation to a contractor for damages which he has actually sustained by their default in the performance of their undertakings to him."

These two cases in the Supreme Court settled the basic principles on this subject and the rules there established in favor of contractors have

the entire period of suspension, for the increase in the price of labor after the contract term during a period equivalent to the period of suspension and for similar increase in other expenses during the same period.

The United States made a contract for excavating in the side channel of the Mississippi River, near Rock Island, and agreed to put a cofferdam across the head of the work and make the pool as "dry as reasonably practicable." The cofferdam broke and delayed the contractors in completing the work. This delay continued so long that the army officer in charge notified the contractors that the pool would have to be flooded to save the dams from destruction during the winter and that he would "not continue the work this winter." The contract term expired in a few days after this notice. Neither party sought to renew the work the next season, but the contractors entered suit in the Court of Claims. The court awarded them the profits which they would have made, had the government kept the pool dry enough for work, and the extra expense which was caused to them by reason of being obliged to pump the water out of the pool while they continued to work.

The government made a contract for marble and brick work at the Memphis Custom House in 1879; the work was suspended by the government



Details of Boiler Flues, Marion Power Station.

on the part of the government itself to be equally prompt in performing the duties which the contract places upon it. They hold the government responsible for the contractor's losses caused by the action of the government's officers in unnecessarily delaying or suspending, or uselessly interfering with, the contractor in his work.

The earliest case on this subject in the Supreme Court was one arising out of a contract made in 1847 for embankment in the now abandoned Memphis Navy Yard. It was claimed that officers of the government interfered with the contractors in performing their work, causing them largely increased expense. The case was argued before the Court of Claims four times and the Supreme Court once. The Supreme Court decided in 1867 that the contractor had a right to recover for the losses caused by improper interference by the officers of the United States and the contractor finally received his pay.

Nine years later the Supreme Court decided a dispute growing out of the construction of buildings for the army post at Beaver, Utah. The contractor was stopped by order of the Post Commander and all work had to be suspended. He objected to the stoppage and appealed to the Quartermaster-General and the Secretary of War, who ordered the work to go on. The suspension

since been followed and applied in many other cases.

The latter case affirmed a principle which the Court of Claims had already announced in a case arising under a contract made in 1855 for erecting the military post at Fort Gaines, Ala. The opinion in that case had made the important declaration that "It cannot be assumed that one party to a contract can wrongfully delay its performance without exposing the other to losses and injuries, for which the law affords redress."

**What Damages Allowed.**—The general principle being thus settled that the government must answer in damages for losses sustained by the government's delay or its interference with the contractor's work, the next question is as to the basis for settling the amount of such damages. An examination of the decided cases will show what rules have been recognized and applied.

In the case of the army post in Utah, the Court of Claims in fixing the damages said that it followed the rule of allowing the contractor "such damages as, with reasonable diligence and prudence on his part, would put him in the same situation at the end of the work that he would have been in if he had not been interfered with."

In the Alabama case, the Court allowed for the workmen who had to be kept under pay during

in July, 1879, on account of the prevalence of yellow fever and was not resumed for about a year and a half. Even before the suspension the contractors lost working days for lack of material which the government was bound to furnish. The Court of Claims allowed the contractors to recover for the pay of employees who were kept under pay unemployed during these lost days, for the advance of labor after the original period of the contract and for the cost of repairing and restoring the plant when they resumed work after the long delay.

A contract was made for dredging the Delaware River in 1879 and the work went on until July, 1880, when the engineer in charge closed the work because the appropriation was exhausted. The work was not resumed and the Court of Claims allowed damages for the suspension, giving the contractor the profits which he would have made, had he been allowed to complete the work, less a deduction of the reasonable value of his care and superintendence during the period required to complete the work.

A contract made in 1881 provided for the building of a dike in the Ohio River. Three thousand feet of sub-structure were to be built the first year. The contractor collected all the material necessary for the work of the entire season

and was prepared to put it into the dike. On September 27th an order was issued to stop the dike at 1,500 feet. The high water of the next winter washed away much of the material collected. He sued for damages resulting from this order of suspension and the court allowed for his personal services and for losses incurred by the washing away of his collected material.

The government delayed for thirteen months the beginning of work under a contract for completing the United States Court House at Chattanooga. The contractors completed their work

Haven, already discussed, the contractors were delayed for eleven months and eighteen days by the failure of the government to furnish plans and specifications promptly and by errors in the plans when furnished. The Court of Claims, in giving damages on account of this delay, allowed for the extra time of the foreman who was kept employed and the extra time of the contractor himself as superintendent, no other items of direct damage being proved.

The contractors for building government wharves at Honolulu were delayed in beginning

contractors gave up the work entirely and sued for their losses by reason of the suspension. The court allowed them the expenditures which they had made on the faith of the contract, less the amount realized by them by the sale of old material and the value of material remaining in their possession.

*Interference.*—Some cases have arisen where the government, instead of delaying the work by neglect or failure to meet its own obligations or suspending it by an express order, interferes with the contractor's mode of carrying on his business, or stops his work entirely so as to hinder him in its execution.

Thus a contract for work on the Des Moines River gave authority to the government engineer to hire additional men, if the work was not progressing satisfactorily, and the engineer notified the contractor during the winter suspension of work of his intention to proceed under this provision. When the contractor arrived on the ground to resume work, he found that the engineer had taken his sub-contractor into the employment of the government. The local inspector also forbade the contractor resuming work. The court treated both of these acts as an unlawful interference with the contractor and allowed him compensation for his losses.

In the construction of the Naval Observatory at Washington, differences arose between one of the contractors and one of the inspectors, resulting in an order that this particular contractor should not be allowed on the premises. The Court of Claims declared that this was beyond the lawful power of the officers of the government, but did not award any damages because of the failure of the evidence to present proper proof of loss.

The contractors for improving the harbor of New Orleans spent a large amount of money in preparing to do the work, when the government engineer concluded that the plan of improvement would not succeed. The contractor was thereupon notified to cease operations and the contract was abandoned. The Court held them entitled to recover for the actual expenses incurred and stated that it would also have allowed for profits which would have been made had the contract been completed except that the proof failed to show that the contract would have resulted profitably.

The Ordnance Department of the government made a large contract for gun cotton and shortly afterwards determined that they did not need the gun cotton at all. The contractor was thereupon notified that the government abandoned the contract. Upon suit in the Court of Claims, the cost of manufacturing gun cotton was shown and the Court allowed the contractors the difference between this and the contract price. This case is rather notable from the circumstances that the contractor, although asserting the loss to have been about \$30,000, offered to the War Department to settle with the United States for \$10,000; that the War Department was willing to recommend \$7,500; but that upon suit in the Court of Claims, where full evidence of the loss was taken subject to careful cross-examination, the court found the actual damages to have been \$24,137.13.

*Rule for Allowing Damages.*—These cases all illustrate the conditions under which damages will be awarded for delays, suspensions and interference and the items which are properly allowable. In some of these cases the Court of Claims has stated the rule by which the damages will be limited. Thus in one case, after allowing the amount actually paid out and a salary to the contractor as superintendent, they said that "These are the only items of damage which were the approximate result of the acts of the defendants, the other items not being such as were within the



Interior of Marion Power Station, Showing Turbo-Generator Units.

and sued for damages. The court allowed them the loss due to the increase in prices of material, the expenses incurred by them during the period of suspension and the value of the personal services of the contractors themselves during the same period.

In the frequently cited case arising at the St. Mary's Falls Canal, the contractors' work was suspended by the officers of the government in July and they were not permitted to resume until the close of September, when cold weather had set in and steam shovels could not be used for continuing the excavation. The contractors continued the work by hand and the court allowed them the increased cost.

In the contract for the Court House at New

their work because the dredge contractors engaged by the United States did not finish dredging a work necessarily precedent to that of the claimants. The Court of Claims allowed them the value of the use of their machinery during the delay and the wages of the crew of six men employed and paid, less the amount earned during the same time.

The latest case involving suspension of work was decided by the Court of Claims in 1903. The Spanish War came on while the reconstruction of a pier of a bridge crossing the Potomac River at Washington was going on under contract. The new demands required a constant and heavy use of the bridge and the Secretary of War ordered the suspension of work under the contract. The

contemplation of the parties when the contract was entered into and are not, therefore, allowable."

Similarly in another case they said: "The measure of the damages to plaintiffs should be the actual and direct loss to them occasioned by the delay, as near as it can be ascertained, not remote or speculative damages that would not have been anticipated by the parties upon the happening of the events that caused the delay."

The government in 1863 made a contract agreeing to furnish hogs to be slaughtered and cured by the contractor for army use. The hogs were not furnished and the contractor sued for damages for the government's thus abandoning the contract. The Supreme Court sustained his contention and approved the rule for damages applied by the Court of Claims: "The difference between the cost of doing the work and what claimants were to receive for it, making reasonable deduction for the less time engaged, and for release from the care, trouble, risk and responsibility attending a full execution of the contract."

*What Damages Not Allowed.*—Some particular instances have occurred in which the Court of Claims has refused to allow items which the contractors considered proper damages for delays. In the case cited where damages were allowed under the building contract at Memphis, the court excluded the wages of men engaged by the contractors after notice of suspension and before notice of probable resumption, deeming such expense unwarranted.

The Supreme Court of the United States had before it a case for damages under a contract for building a monitor in the Civil War. The disputed item of the claim arose out of the government's delay, by which the time of work was greatly prolonged. It was asserted that prices had risen to such an extent that the execution of the work cost much more than contemplated by the contract. The evidence showed that the rise in prices was chiefly during the contract term and consequently that the contractor, even had he been permitted to finish during the contract term, would have finished the work at a great loss. The special statute under which this case was heard provided that the court could not consider any claim based on an increase of prices during the contract term and the court held that this limited its right to give relief.

That this rule, if applied generally, where not required by a special statute, would work hardship is seen by an item of claim now pending before the Court of Claims in the writers' practice under the contract for building the Boston Dry Dock. The contractors made early arrangements for delivery of stone on a favorable basis and deliveries promptly began. The government would not inspect the stone, would make no advances upon it and would not even furnish yard room for storage. For these reasons deliveries had to cease and when the government was ready to receive and inspect stone, the market price had risen enormously, to the contractors' great loss. Claim is now made for the resulting loss. It would seem here that whether the rise were within the original contract term or not is quite immaterial.

A somewhat hard rule was established by the Court of Claims under a stringent provision of statute in a case arising out of the contract for the construction of the Monadnock. This contract was made in October, 1875, and the vessel, without fault on the contractor's part, was not completed until November, 1883, the delay being on the part of the government in furnishing plans and delivering materials. Payments were also delayed. The court allowed a large number of items of the direct loss on account of these delays, amounting to \$129,811.45. During the pendency of the contract, by reason of the delays

in making payments, the contractor was obliged to borrow money and he paid interest on it, amounting to nearly \$35,000. The Court of Claims held that the express statute forbidding it to allow interest was so broad that it not only could not allow interest upon money withheld by the United States, but could not even allow interest as an item of expense in estimating damages.

Some doubt has been cast upon the correctness of this decision by a later case in the Supreme Court of the United States, where interest was allowed under somewhat different conditions as an item of expense. The question may therefore be considered as still open for consideration before the Supreme Court of the United States.

*Completion after Suspension.*—If the contractor upon a construction project completes his work after suspension, we have already seen that the courts allow him not only his contract price, but also any increase in the price of labor after the expiration of the contract term and other direct losses. If the contract is for the delivery of materials or supplies, the Supreme Court has announced a different rule, which cannot in some aspects be reconciled with this. The decision was made in a case where a contractor

visions protecting the United States from the consequences of its own officer's defaults. Of late years some of the river and harbor contracts of the War Department have contained express provisions like the following, designed to protect the United States from the consequence of the delays of its officers:

"Should available funds become exhausted, the contractor will be duly notified, and he is given the option to continue the work as rapidly as possible under the law and contract, relying upon future appropriations for payment, or to suspend operations until such appropriations are actually made and available."

"It is distinctly understood and agreed that the contractor assumes all risks, and that the United States is in no case to be held liable for damages under or in connection with this contract on account of delays in the work due to any cause or in payments due to lack of available funds."

In the absence of such provision as the first of these, it was held in a case already referred to that the contractor could under certain conditions hold the United States responsible for his losses arising from suspension caused by exhaustion of



Piling and Concrete Foundation, Marion Power Station.

had agreed to deliver oats to an army post, during the Civil War, and the government had refused to receive them when delivered. At the expiration of the contract term, the contractor notified the quartermaster that the contract was at an end. The price of oats having advanced, the contractor lost nothing by the refusal to receive his oats, as he could have sold them for more than the contract price. After this the quartermaster called upon him to complete the contract. The contractor objected, but delivered the oats and sued for the difference between the contract price and the market price when delivered. The Supreme Court declared that in delivering the goods under the contract, he delivered them at the contract price and could get nothing more. This rule has ever since been followed and contractors for the delivery of supplies who wish to reserve their rights must refuse to go on with deliveries after the contract term or they will be presumed to have waived their right to a higher price.

*Special Provisions.*—All the decisions already cited in regard to delays and suspensions have been under contracts containing no special pro-

visions. This provision protects the government against all such possibilities of loss. The constitutional right of Congress to control appropriations may justify this provision, although the contractor assumes an obligation which naturally belongs to the United States.

Under the second provision the contractor, who must assume all liability on account of his own delay, a liability enforced by stringent provisions for annulment as well as by penalties for delay, is actually obliged to assume sole responsibility for all delays, however flagrant, on the part of the officers of the United States. The provision is essentially unfair and calculated to repel contractors from taking government contracts.

One-sided provisions like this which have crept into government contracts of recent years introduce an element of uncertainty which must repel many contractors from government work or, if they bid, at all, must greatly increase the amount of their bids. They tend to make government contracts, instead of legitimate commercial enterprises, little more than, to use the language of a distinguished government engineer, "a gamble." The lack of a sense of personal re-

sponsibility on the part of the officer in charge is often a serious embarrassment in governmental work and such provisions increase this evil.

This provision has not yet come before the courts. When it comes it is easy to predict that it will be sustained as an agreement of the contracting parties within their power to make and therefore to be enforced as written, but it may further be predicted that the courts, recognizing its essential unfairness, will limit its operation strictly to its terms. Thus it will probably be held to include only negative delay and not positive interference with contractors' work or even direct suspension of work.

*Practical Rules.*—This chapter having been devoted to the discussion of rights arising out of suspension or interference by government officers, practical rules of conduct for the guidance and protection of contractors under such conditions must be chiefly confined to a statement of the course to be followed when their rights are so invaded.

1. The contractor should determine immediately upon his work being suspended or interfered with whether it is to his interest to abandon his contract or to submit to the delay and continue the work.

2. If he determines to abandon the contract, he should give immediate notice of it to the highest officer approving the original contract and such additional notice to subordinate officers in immediate charge as may seem necessary, stating clearly his reasons for so doing and announcing his purpose to claim damages.

3. If he proposes to go on with the contract at the conclusion of the suspension, he should in good faith reduce his expenses in all possible ways during the period of suspension, since the courts will allow him only for absolutely necessary expenses. It is the part of prudence also to give like notice of his intention to claim damages for losses incurred.

To this may be added one more caution:

4. A contractor, before bidding, should always ascertain whether responsibility for delays on the part of government officers is cast upon him by the contract or specifications. If he is to be answerable for causes thus entirely out of his contract, he should then decide whether he will bid at all, and, if he determines to bid, whether an allowance must be made in the bid for possible contingencies under such a clause.

(To be Continued.)

A HIGH RATE OF COMBUSTION is one of the principles often claimed as an essential to the best economy in the generation of steam. The idea is to reduce the proportion which the final temperature bears to the initial temperature of the furnace and thereby the proportionate amount of unused heat. To this end the plant is provided with a tall chimney so as to get the necessary draft, and the number of boilers is reduced, thus throwing the desired amount of work upon each furnace. At the same time a feed-water heater is placed in the flue to absorb the waste heat and reduce the temperature of the chimney gases to the lowest point attainable. With a given flue temperature it is apparent that the proportion which the lost heat bears to the heat generated is less the higher the furnace temperature, and consequently as the furnace temperature increases, the efficiency of the boiler increases. More than this, if in connection with an increased furnace temperature there is a lower flue temperature, the gain in efficiency is twofold. Other things being the same, it is evident that a rapid combustion in the furnace is a condition which is favorable to economy where measures are provided for absorbing the extra heat thus generated.

## The Official Test of the Engines of the Subway Power Station, New York.

In accordance with the terms of the contract between the Allis-Chalmers Co. and the Interborough Rapid Transit Co., governing the construction and operation of the nine double-cross-compound engines in the latter's power station at 59th St. and 11th Ave., New York, the former guaranteed certain operative results under specified conditions, in effect as follows:

Each engine was not to require more than 12.25 lb. of dry steam per indicated horse-power per hour when indicating 7,500 h.-p. at 75 r. p. m., with a vacuum of 26 in. at the low pressure cylinders, and with a steam pressure at the throttle of 175 lb., this rating to include all steam used by the engine or by the jackets or reheater. A further agreement governed in detail the conduct of the test, because of certain features peculiar to the case involving the essential point of the original contract. The swing of the generator lead, averaging approximately 12 per cent. in three seconds plus or minus, presented a prohibitive impediment to the use of the ordinary engine indicator as a standard for results. Thus the only method practicable was to obtain the developed electrical horse-power of the unit and correct this by engine friction and generator losses as determined by subsidiary tests, these tests becoming practically of primary importance, as indicated by results of preliminary trials. The final decision was to make friction determinations by two methods, an electrical and a continuous indicator method, the former to be considered decisive if checked within 10 per cent. by the latter.

Following is a description of the conduct of the test proper and the subsidiary tests, classified as reported by the engineer in charge of each department of the test:

*Engine and Steam Readings.* The engine designated as No. 8, being so situated as to permit unit isolation from the rest of the plant, was selected as representative of the complete installation. All steam and water mains and auxiliary lines in the unit were either entirely cut off from the rest of the house or separated by two valves and a bleeder or drip valve between. The unit as thus isolated consisted of seven boilers, the water ends of a boiler feed pump and a circulating pump respectively, and the main engines.

For weighing the total feed water as delivered by the supply line, four tanks, mounted in pairs upon two 20-ton scales, with a capacity per pair of 28,000 lb. of water, were used. The delivery from the weighing tanks was to two reservoir tanks connected by equalizers, and then in turn to the boiler feed pump. For weighing of drips, leakage, etc., small scales and tanks were erected as necessary. Peabody throttling calorimeters were connected to the main line, in close proximity to the throttle, for use in case of wet steam. All gauges and thermometers were carefully calibrated and standardized to the satisfaction of both parties. For the purpose of correcting for changes of level of the water in the boilers, scales graduated to tenths of an inch were placed close to each gauge glass, and a temporary walkway erected to facilitate readings. Floats indicated the level of the reservoir tanks, this level being maintained a constant. To eliminate the use of the calorimeters, the steam supply was maintained at a constant low degree of superheat, one boiler containing superheater coils and this operated as desired. Vacuum was maintained at an average of 26 in. mercury. Due allowance was made for all known leakage and drips. Readings were taken at 15-minute intervals, an hourly graphical log being maintained.

*Electrical Readings and Determinations.*—The load on the engine was measured electrically by

means of four balanced three-phase integrating wattmeters of the induction type, connected to current and potential transformers, located at the terminals of the alternator, and connected as follows: Three current transformers, one in series with each of the three armature conductors, and two potential transformers, connected from phases 1 to 2 and 2 to 3 respectively.

As the potential transformers were designed for use under closely defined conditions, and could therefore be accurately standardized by the makers, their ratio, which is 100 to 1, was assumed to be correct. In the case of current transformers, however, where the ratio is subject to change, due to changed secondary resistance, it was considered desirable to re-check the ratios, which was done as follows:

The generator was short-circuited with a standard Kelvin ampere balance in series with the current transformer in phase 1, while a portable ammeter was substituted for the regular switch-board ammeter in the secondary side, thereby securing accurate measurement of the secondary current without altering the secondary resistance appreciably, while all other instruments having a current winding, which were to be used for the test, were included in the circuit.

The generator was then run at full speed, and the excitation adjusted to cause the full load current of 263 amperes in the armature, which was found to be constant. During this period, 20 readings of primary and secondary current were taken simultaneously by means of telephone communication between the readers of the Kelvin balance and secondary ammeter. From these corrected readings the true ratio of transformation was calculated. It can be seen that this method of test, which is made under operating conditions, will correct for any error due to inductance in the secondary circuit, caused by running the current transformer leads in iron pipes, which could not be provided for in the original manufacturer's ratio test. This test was repeated for phases 2 and 3 under similar conditions.

The calibrating watts for the four balanced three-phase wattmeters were calculated from the corrected transformer ratios, and the meters calibrated and adjusted by comparison with Weston standard wattmeters, the calibration of which will be described later.

The meters were connected as follows: One in the secondary of the current transformers in phases 1 and 3 respectively, and two in that of phase 2, the object of this method being to show by the readings of the meters in the three phases that the load was balanced, while the object of the two meters in a single phase was to furnish a continual check on the calibration of the meters. It was found that all meters agreed within their limit of precision, and results were therefore calculated from the average of the readings of the four meters, which was taken to be the true output of the generator in KwH.

*Friction Determination; Electrical Method.*—The combined losses in the unit were ascertained by driving the generator as a synchronous motor with the engine trailing, and measuring the watts input, which it can be seen would consist of combined friction and windage, I<sup>2</sup>R losses and iron losses. As this input was too small to be measured accurately by means of the four load meters, a special meter with its standardized current transformer was used.

The unit could not be motorized for periods longer than five minutes because of the difficulty in lubricating the cylinders, which was not long enough to give a dial reading on the meter, so the meter during the short run was read by counting the revolutions of the disc, timing them with two chronograph watches reading to tenths of a second intervals in order to obtain the power factor, calibrating formula. During this period, the field

current was held at that value corresponding to full load excitation in order to make the iron losses the same as at full load, and was read on a Weston standard portable ammeter. The armature volts and amperes were also read at 10-second intervals in order to obtain the power factor, which, due to the over-excitation of the field at such small load, was low, averaging for the several trials 18.5 per cent. with a leading current. As the meter used for this test was calibrated at a power factor of 1.0, it was necessary to check it on low values, and readings were therefore taken with a leading current at 10 points from 0.1 to 1.0, and a curve plotted, showing the error, which curve was used to correct all readings taken on friction trials. To this corrected input, as the armature current was below full load value, must be added the difference between the I'R losses at the observed value and that corresponding to full load current. From the above, the output of the generator plus the input to the generator motorized plus the difference between the I'R loss at motor current and the same at full load current equals the total load on the engine in kilowatts.

**Calibration of Meters.**—The Kelvin ampere balance used for ratio tests was compared with potentiometer and standard resistance. The ammeter for secondary current was compared with the current dynamometer, standardized by means of potentiometer and standard resistance. The current transformer for friction trials was checked by comparison with the Kelvin ampere balance. The standard indicating wattmeters used for calibrating integrating wattmeters were checked by comparison with a Weston laboratory standard voltmeter, and potentiometer and standard resistance. The Weston standard portable shunt and millivoltmeter was checked by comparison with potentiometer and standard resistance.

The work of calibrating the standards was performed by the Electrical Testing Laboratories of New York in all cases, and in addition, by comparison with the Interborough Rapid Transit Co.'s own standards whenever possible, in all of which cases the same agreed within the limits of precision of the instruments tested.

**Friction Determination by Continuous Indicator.**—For this purpose, a continuous indicator was designed by Mr. W. L. Seabrooke of the Interborough, which instrument solved the problem of indicator application to the engine. Following is a short description of the device:

This consists of two drums, *A* and *B*, turning freely on spindles *CC*, mounted on the mandrel *D*, which has a reciprocating movement in front of the indicator *E*, the latter being of regular standard design except for the removal of the drum. A strip of paper winding on *A* from *B* passes over the plate *F*, thus presenting a flat recording surface. As the back-pressure line is traced, the ratchet *G* contacts with the toothed wheel under the drum *A*, causing it to rotate a fixed distance. This movement defines the distance between successive cards, and can take place at any point of the stroke desired. As the back-pressure line is usually straight, no error is introduced and the cards present the same appearance as if taken singly. The operation is automatic and records a card for each revolution to the extent of the paper supplied by the drum *B*.

Using this device, two sets of indicator cards were taken on the engine running empty; one for a period of two minutes with an exciter current of 165 amperes, and the other for a period of one and one-half minutes without the exciter.

**Leakage Test.**—A leakage test of the boilers, and boiler feed and steam lines to the engine throttle was made 36 hours subsequent to the official engine trial, and was of 24 hours duration. In connection with it, water was weighed and fed to the boilers by way of the reservoir tanks, as

in the engine test. Due allowance was made for all known leakage and drips, and correction made for change in boiler level.

#### RESULTS OF FRICTION TRIALS (Electrical Method).

|                                             |                |
|---------------------------------------------|----------------|
| Volts, armature by switchboard meter.....   | 10,510 volts.  |
| Amperes, armature by switchboard meter..... | 119.6 amperes. |
| Amperes, field by Weston standard.....      | 202.2 amperes. |
| Kilovolt-amperes, armature.....             | 2,170 K.V.A.   |
| Power factor .....                          | 18.55%         |
| Kw. input .....                             | 402.5 k.w.     |
| I'R on test .....                           | 4.12 k.w.      |
| I'R at full load .....                      | 18.92 k.w.     |
| Total losses .....                          | 417.3 k.w.     |
| Resistance of armature at 30° C.....        | 0.2877 ohm.    |

The value 417.3 k.w. is therefore added to all full-load output readings, to obtain total load on the engine.

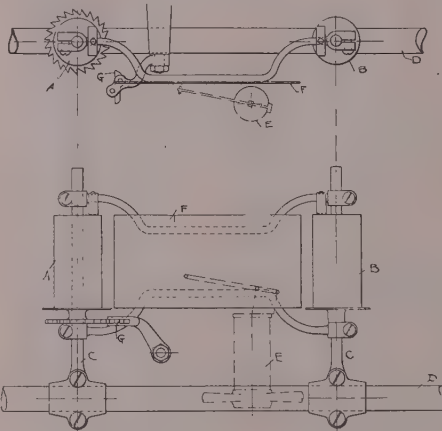
#### RESULTS OF FRICTION TRIALS.

(Continuous Indicator Method.)

|                                            |               |
|--------------------------------------------|---------------|
| With exciter current, engine empty.....    | 580.78 I.H.P. |
| Without exciter current, engine empty..... | 432.7 I.H.P.  |

#### RESULTS OF ENGINE TRIAL, DECEMBER 6, 1905.

|                                           |                |
|-------------------------------------------|----------------|
| Duration .....                            | 15 hours       |
| Preliminary operation on load.....        | 2 hours        |
| Load (switchboard reading).....           | 5079.2 k.w.    |
| Friction and electrical losses.....       | 417.3 k.w.     |
| Total load .....                          | 5496.5 k.w.    |
| Indicated horse-power .....               | 7365.3         |
| Revolutions per minute .....              | 75.02          |
| Steam pressure, gauge.....                | 175.18 lb.     |
| R.-H. receiver pressure.....              | 19.1 lb.       |
| L.-H. receiver pressure.....              | 19.27 lb.      |
| Vacuum .....                              | 26.02 in.      |
| Barometer .....                           | 30.5 in.       |
| Temperature injection water.....          | 42.36° F.      |
| Temperature R.-H. discharge.....          | 74.05° F.      |
| Temperature L.-H. discharge.....          | 77.38° F.      |
| Water per hour.....                       | 89,906 lb.     |
| Weighted leakage per hour.....            | 512 lb.        |
| Leakage per hour (leakage test).....      | 1470 lb.       |
| Boiler level correction per hour.....     | .60 lb. (high) |
| Hot water per hour.....                   | 87,864 lb.     |
| Correction for superheat.....             | 0.28%          |
| Equivalent dry steam per hour.....        | 88,110 lb.     |
| Dry steam per kw.-hour (switchboard)..... | 17.34 lb.      |
| Dry steam per I.H.P.-hour (engine).....   | 11.90 lb.      |



Continuous Recording Indicator.

The tests were under the supervision of Mr. Frank N. Waterman, who acted as referee. The following represented their several companies: Interborough Rapid Transit Co., H. G. Stott, superintendent motive power; J. Van Vleck, mechanical engineer; H. W. Butler, principal assistant engineer; Thomas Allsop, mechanical engineer, 59th St. station; C. W. Ricker, electrical superintendent; G. F. Challis, instrument man; W. L. Seabrooke and W. S. Finlay, assistant engineers. Allis-Chalmers Co., A. M. Mattice, chief engineer; Samuel Moore, district superintendent of erection; T. T. Hubbard, engineer test; J. E. Lord, sales representative; C. A. Hoppen and C. J. Larson, construction department; A. F. Rolf and F. Buch, electrical representatives.

**STEEL BARGES** for the coal trade on the Ohio River are rapidly coming into favor, a large number having been introduced into the "short trade" between Pittsburg, Cincinnati, Louisville and Cairo, as well as into the "long trade" to Mississippi River ports. They are usually about 135 ft. long, 26 ft. wide and 8 ft. deep, having capacities of 15,000 and 16,000 bushels or 600 tons on a draught of 6½ ft.; those for the long trade have been built 170 ft. long and hold 950 tons. They offer many economic advantages over the usual wooden construction, such as greater strength, less liability to leakage and an average life probably three times greater.

## A New Machine for Bending Tests.

By E. Probst, Civ. Eng., Zürich.

The ever-increasing importance in recent years of tests of building materials and building construction, and especially of the experiments which have taken so prominent a place since the introduction of reinforced concrete, has given rise to a number of more or less successful testing machines. One of these I wish to describe. It has, for three years, been in use in the Institute for the Testing of Materials in Zürich, having been built in accordance with the ideas of Prof. Schüle by Messrs. Amsler-Laffon in Schaffhausen, and combines unusual simplicity and precision with a number of other advantages over former machines for bending tests. It should be mentioned that the machine owes its origin to the working out of the Swiss standards for concrete and reinforced concrete, and that the first incentive for the building of this machine was given at the beginning of the work of the Commission chosen for these experiments, as it was a matter of impossibility to obtain accurate results with former machines.

Former machines consist for the most part of an apparatus which causes a concentrated load to work at the middle of a beam in such a way that the beam under experiment is bent little, by little, until a breaking of the beam or a sinking of the load sets in, on account of excessive bending, or flowing of the material. The concentrated load is caused by a ram which also has the effect of holding the beam fast at the points of support and at the point where the concentrated load works; this is, therefore, not a perfectly free support.

An experiment to overcome this defect in bending tests was made by substituting for the middle edge, two edges symmetrical to the middle, which exert, by means of balance arms, equal forces on the beam to be tested. This provides a space between the two edges advantageous for the measurement of the strains, in consequence of the moments of bending remaining equal between these two points.

The machine under discussion, working at the Swiss Testing Institute carries out the experiments in such a manner that it causes a uniformly distributed load. The most important parts of this machine are schematically illustrated in the drawing.

The load is applied by seven pistons, with a variable distance from centre to centre, but 50 cm. is usually advantageous, as in the experiments at the Institute. In this manner the equally distributed load per running meter is obtained by doubling the load working in one point. Pistons without friction are used for loading. Every press is provided at the bottom with a steel sphere; above are two tipping pieces, *k*<sub>1</sub> and *k*<sub>2</sub>. It is evident that each cylinder *c* will only exert a force along its axis, but that there is no side support of the beam under experiment at the point of contact with the load. By raising the load the beam is therefore assigned to its own stiffness against breaking on the side. The presses *p* are driven with Ricinus oil. Before the commencement of the experiment the pistons *k* must be placed exactly vertical, which is made possible by each cylinder possessing underneath four bolts, *b*, fitted with spiral springs. A pump driven by hand or motor and connected by pipes with the separate cylinders causes the raising and sinking of the pistons. The load is read off from scales, by means of mercury columns. Each machine possesses two scales, one up to 3 tons, the other to 18 tons per press, so that a load of 126 tons can be produced by this machine.

The beams are supported on the edges, *e*, which are fitted in frames, which in its turn swings on its lowest part, with the result that the changes

of strain in the fibers, supported at the ends, remain without influence on the inner strains.

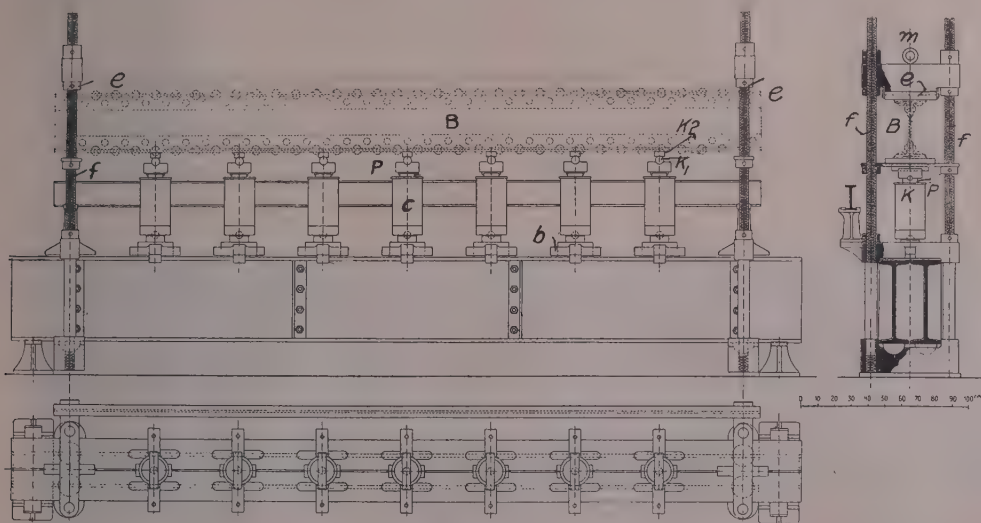
The beam *B* to be tested is placed with great accuracy in such a position that all the forces can work exactly in the center plane, *M*, of the beam. Unless this is carried out with great precision, the fault is noticeable shortly after the commencement of the loading in the distortion of the beam. After placing the beam in position on the cylinders, *c*, the axis of the body will fall in a vertical plane with that of the cylinders. The center line of the two edges must also fall in this vertical plane. Instruments for measuring the bending are applied in the middle and at both

### The Cost of Power from Blast Furnace Gases.

One of the most complete analyses yet made public of the cost of producing power from blast-furnace gas is given in a paper presented before the Western Society of Engineers on December 20 by Mr. H. Freyn, engineer of the gas engine department of The Wellman-Seaver-Morgan Co., of Cleveland. He based his analysis on the conditions in a new plant of two 400-ton blast furnaces, situated in the immediate vicinity of a large city and having the ordinary facilities for wa-

of this blast furnace will be about 90 B.t.u. per cu. ft. The total quantity of gas available for the various purposes in this blast furnace plant amounts to  $130,000 \times 800 = 104,000,000$  cu. ft. of gas per 24 hours or 4,350,000 cu. ft. per hour, having a total heat value of 391,500,000 B.t.u. Modern double acting gas engines of large capacity working on the four-cycle or Otto principle, built with the latest improvements and using high compression of mixture, consume less than 9,000 B.t.u. per brake horse-power per hour at full load capacity. The total quantity of gas produced by two blast furnaces of 400 tons capacity each, when used in gas engines for generating power, would operate at least  $391,500,000 \div 9,000 = 43,500$  h.-p. per hour. If, therefore, all the gas generated by a blast furnace plant could be used for producing power, there would be available over 50 h.-p. per ton of pig iron produced per 24 hours.

**Hot Blast Stoves.**—It is generally figured that about 30 per cent. of the total quantity of gas generated by the blast furnace is required for heating the blast, although this quantity varies considerably according to the quality of the gas, the design and construction of the hot blast stoves and according to the conditions of operation of the blast furnace plant in general. Very exhaustive tests as to the advantage of cleaning the gas for stoves and boilers have been made by Mr. Emil Hiertz, superintendent of the blast furnaces of the John Cockerill Co., of Seraing, Belgium. As far as gas consumption of the hot blast stoves is concerned he found that by using clean gas the temperatures of the stoves could be increased at least 200° F. This fact tends to decrease the quantity of gas necessary for obtaining a certain temperature in the hot blast stoves, so that in the



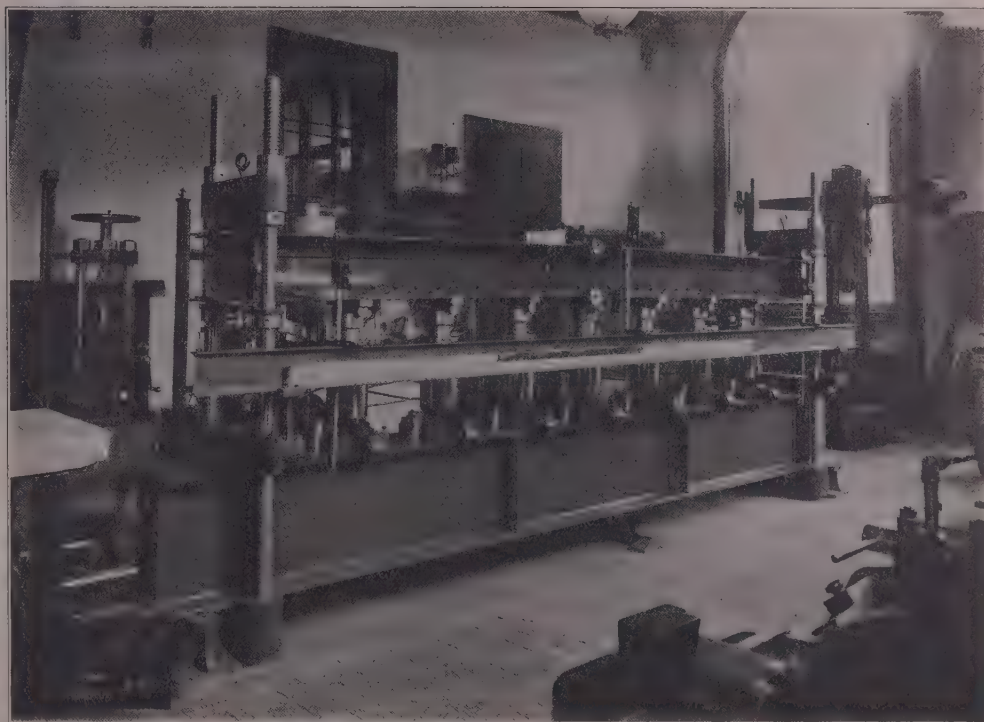
Details of Machine for Bending Tests.

ends, and the actual bending in the middle is the difference of the middle reading and the arithmetical mean of the readings at the two points of support. The other arrangements for measuring the strains in certain parts of the beam are the same as for other machines.

By raising the pistons, which are controlled according to a scale, the load is brought into action. The experiment can be carried on so far that a very large bending takes place. Absolute breaking is very seldom done by the machine; but this is quite irrelevant in beams under the influence of bending, since the question is to discover the stiffness of the beam and not the breaking-point. In our case, the span of the machine was 4 m.; from this it follows that the length of the beams to be tested can be nearly 4.30 m. By laying the beam on the pistons, without laying it upon the edges, the weight of the beam may be determined with a fair degree of accuracy, a distinct advantage when large, heavy beams are in use.

This machine is as applicable in practice as well as in the laboratories, and has the great advantage that bodies of large dimensions can be tested, and that the load can be made to rise and fall in rapid succession, which is specially useful in determining the changes of strain by often repeated loading. The equal distribution of the load over the whole length of the beam by the pistons results in the deformations and changes of strain of the whole body being readily seen, a fact of special importance in the testing of reinforced concrete.

Tests have been made with the machine on rolled and riveted girders, as shown in the illustrations. In the pictures, the measuring arrangements in the middle and at the points of support, as well as the measures for the strains are visible. Tests have also been made on Siegwart beams of reinforced concrete. At the present time, the machine is being used for tests of reinforced concrete, according to the rules of the Swiss Commission on Concrete.



Machine for Bending Tests. Used by Institute for Testing Materials Zurich.

ter supply and for handling the raw and finished material. Assuming both furnaces in good operation and assuming a coke consumption of 1,900 lb. per ton of pig iron, there will be required  $800 \times 1,900 = 1,520,000$  lb. of coke per day. This quantity of coke produces approximately 110,000,000 cu. ft. of gas in 24 hours, or, per ton of pig iron  $110,000,000 \div 800 = 137,000$  cu. ft. of gas. The losses on the top of the furnaces may amount to approximately 5 per cent., so that 130,000 cu. ft. of gas per ton of pig iron produced in 24 hours could be obtained. The average heat value

future the percentage of gas to go into the stoves will be materially decreased. Assuming the figure of 30 per cent., the total quantity of gas necessary for heating the blast will be  $4,350,000 \times 0.30 = 1,305,000$  cu. ft. per hour.

**Gas Blowing Engines.**—A new blast furnace plant will, in the future, be equipped with one steam blowing engine for starting the blast furnaces, unless gas producers should be installed, while the rest of the blowing engines will be operated by gas engines. The quantity of blast required will be 90 cu. ft. per minute per ton of pig

iron produced, or for 800 tons;  $800 \times 90 = 72,000$  cu. ft. of blast per minute.

Assuming that all the necessary blast be furnished by gas blowing engines, the latter will normally have to compress the blast to about 15 to 18 lb. per square inch, but as it will be occasionally necessary to blow against a pressure of 30 lb. per square inch, the gas blowing engines must be large enough to do this work. Figuring on a maximum pressure of about 30 lb., the work necessary to compress 100 cu. ft. of air against this pressure for adiabatic compression will amount to 8.65 h.-p. theoretical, or nearly 10 h.-p. in the gas engine. As 72,000 cu. ft. per minute have to be compressed,  $720 \times 10$ , or 7,200 h.-p. in gas engines must be provided for. The engines would, under these conditions, operate under full load. The heat consumption, as stated before, will be less than 9,000 B.t.u. per horse-power-hour, but assuming that 9,000 B.t.u. one horse-power-hour will require  $9,000 \div 90 = 100$  cu. ft. of gas, and 7,200 h.-p. in blowing engines will therefore require 720,000 cu. ft. of gas per hour.

Under ordinary conditions, the gas blowing engines will have to blow against only 15 to 18 lb. pressure. Taking the lower figure of 15 lb. there will be required 5,125 h.-p. per 100 cu. ft. of blast theoretically, or approximately 6 h.-p. per 100 cu. ft. in the blowing engines. For the total quantity of blast of 72,000 cu. ft. per minute, there will be required  $720 \times 6 = 4,320$  h.-p. The gas blowing engines are supposed to be ample in size to give a maximum of 7,200 h.-p. They would, therefore, operate normally on 60 per cent. of their full load capacity.

**Auxiliary Machinery.**—The power necessary for lighting the plant, for pumps, hoists, and all the necessary machinery for operating the blast furnace plant, could be assumed to be about 1.5 h.-p. per ton of pig iron produced per day. This figure will take into account all the modern machinery with which an up-to-date blast furnace plant is equipped, and is certainly very conservative, as others estimate the auxiliary power to be far less. A. Ernst gives the figure of 1 h.-p. per ton of pig iron produced, Edward Uehling gives about 1.04 h.-p., W. Oswald gives 1 h.-p., and the John Cockerill Co. about 1.05 h.-p. per ton of pig iron produced. At the rate of 1.5 h.-p. per ton of pig iron for auxiliary machinery, the total requirements for the blast furnace plant of 800 tons will amount to  $800 \times 1.5 = 1,200$  h.-p. If this power be generated by gas engines and assuming a gas consumption of 100 cu. ft. per h.-p.-hour, the total quantity of gas to be deducted for auxiliary power purposes will be  $1,200 \times 100 = 120,000$  cu. ft.

**Gas Cleaning.**—It has been already indicated that a modern blast furnace plant will be equipped, in the future, with extensive gas cleaning apparatus, to cleanse all the gas produced by the furnaces. Aside from the advantage of obtaining a higher temperature in the hot-blast stoves, thus decreasing the quantity of gas necessary for heating the blast and eventually decreasing the coke consumption per ton of pig iron produced, there is a decided advantage in using clean gas for heating the stoves, as the latter do not require to be cleaned as often.

That the clean blast furnace gas is by far more advantageous in its use, than dirty gas, is shown by an experience had at the blast furnace plant at Seraing. It required with dirty gas 3 hours' time to get up steam pressure in a clean boiler, while by using clean gas, this time could be reduced to 1½ hours. It is a well known fact that clean gas burns far better than gas containing considerable quantities of very fine dust.

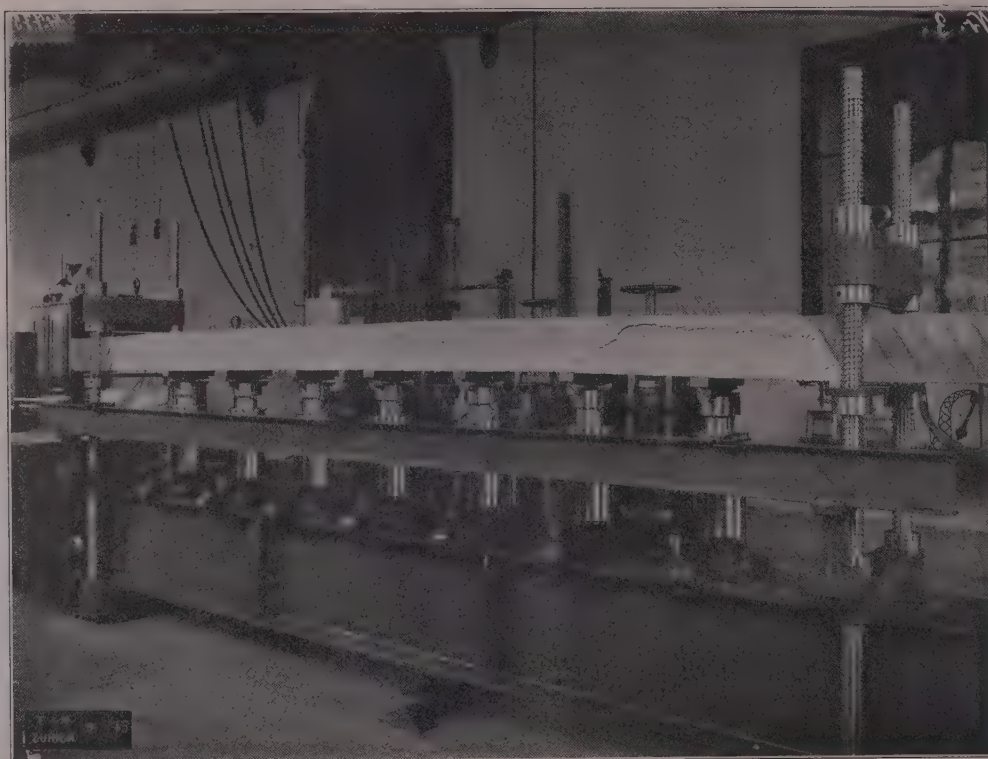
In Europe, the centrifugal gas cleaning apparatus invented by Mr. Edward Theisen is used almost exclusively for gas cleaning plants. According to the experience as indicated by Euro-

pean practice for cleaning the gas generated by the blast furnaces, it may be assumed that all the gas for our 800-ton blast furnace plant is to be cleansed in Theisen gas washers of large capacity, to such an extent as not to contain more than about 0.5 gram of dust per cubic meter. The part of the gas for operating gas engines will be subjected to a further cleaning in Theisen gas washers, which will bring down the amount of dust contained in the gas to 0.03 gram per cubic meter.

In order to clean 10,000 cu. ft. of gas per hour to such a degree of cleanliness as to be suitable for the hot blast stoves, the Theisen gas washers require about 1.25 h.-p. The power necessary for cleaning the whole quantity of 4,350,000 cu. ft. of gas per hour will therefore amount to  $435 \times 1.25 = 550$  h.-p. As stated before, 30 per cent. of this clean gas goes to the stoves, leaving 70 per cent. to pass through the second series of Theisen gas washers. The power required for the second series of gas washers will therefore amount to  $0.7 \times 435 \times 1.5 = 460$  h.-p. and the total power required for gas washing

poses, in round figures 2,000,000 cu. ft. of gas per hour. This quantity of gas at the rate of 100 cu. ft. per h.-p. per hour would provide for 20,000 h.-p. Per one ton of pig iron produced per 24 hours, there will therefore be available for sale or for other useful work 25 h.-p. As found previously, the total quantity of gas generated by two 400-ton furnaces represents over 50 h.-p. per ton of pig iron produced per 24 hours.

The blast furnaces are subject to certain unavoidable irregularities on account of which a "coefficient of safety" must be introduced in the calculation for determining the available power from a blast furnace of a given capacity. This coefficient is of course extremely variable and depends largely upon the pig iron market (which might require a banking of the furnaces), upon the operation of the furnaces, the quality and supply of ore, coke, etc. With two blast furnaces only it would be perfectly safe to figure on the available horse-power from the gas of one furnace only, assuming this coefficient to be 0.5. The following calculation has been made on the assumption that an electric power plant of about



Machine for Bending Tests, Used by Institute for Testing Materials, Zurich.

purposes will be 1,100 h.-p. Gas dynamos will generate the necessary electric current for operating the electric motors of the gas washers. With a combined efficiency of 85 per cent., the required capacity of the gas engine will be about 1,200 h.-p. and at the rate of 100 cu. ft. of gas per h.-p. per hour, there will be required for gas cleaning purposes another  $1,200 \times 100 = 120,000$  cu. ft. of gas per hour. Figuring back on the tonnage of pig iron, it will be seen that the power required for gas cleaning purposes amounts to about 1.5 h.-p. per ton of pig iron produced in 24 hours. This figure coincides very nicely with the figure given by W. Oswald, of Coblenz, which is 1.6 h.-p. per ton of pig iron produced in 24 hours.

**Losses.**—In the piping for the engines, in the gas engines themselves and in the gas cleaning plant, about 5 per cent. of the gas required might be lost by leakage, etc. The total loss would, therefore amount to  $0.05 \times 960,000 = 48,000$  cu. ft.

After deducting the quantities of gas necessary for the various purposes of the blast furnace plant there remains available for other pur-

poses, 10,000 h.-p. be installed first. The size of unit best suited for this power plant would be an engine of about 1,500 h.-p. capacity. Seven gas engines of 1,500 h.-p. rated capacity would develop 10,500 h.-p. In order to meet emergencies an eighth engine as a standby or spare unit should be installed, so that the power plant in the beginning would consist of eight units as above.

| COST OF INSTALLATION AND FIXED CHARGES.     |          |           |          |         |
|---------------------------------------------|----------|-----------|----------|---------|
|                                             | Cost.    | Life.     | Charges. | Total.  |
| Gas cleaning plant.....                     | \$33,500 | 8.31 yr.  | 16%      | \$5,300 |
| Building and foundations for cleaners ..... | 6,500    | 16.62 yr. | 10%      | 650     |
| Ring gas main.....                          | 6,000    | 14.21 yr. | 11%      | 600     |
| Engine building .....                       | 45,000   | 16.62 yr. | 10%      | 4,500   |
| Engine foundations .....                    | 26,000   | 16.62 yr. | 10%      | 2,600   |
| Traveling crane .....                       | 8,500    | 14.21 yr. | 11½%     | 930     |
| Eight gas engines.....                      | 424,000  | 9.95 yr.  | 14%      | 59,360  |
| Complete piping .....                       | 24,000   | 14.21 yr. | 11%      | 2,640   |
| Air compressor outfit..                     | 5,000    | 14.21 yr. | 11%      | 550     |
| Complete elec'l equipm't                    | 162,500  | 9.95 yr.  | 14%      | 22,750  |
| Total .....                                 | 741,000  | .....     | .....    | 100,000 |
| Cost per h.-p. (12,000 h.-p. rating) .....  | 61.60    | .....     | .....    | .....   |
| Cost per kw. (8,300 kw. rating) .....       | 89.50    | .....     | .....    | .....   |

NOTE: Interest is figured at 5 per cent., insurance at 1 per cent., and depreciation at 4 to 10 per cent., according to assumed life of items of plant.

Generators of 800 kw. would, at the rated load

of the gas engines of 1,500 b.h.p., develop about 1,000 kw. or 800 kw. plus 25 per cent. overload. At maximum load of the gas engines of 1,650 b.h.p., the generators would carry 1,120 kw. each.

**Power Station.**—The part of the gas washing plant chargeable to the power house has to clean a maximum of 1,200,000 cu. ft. of gas per hour, provided all eight gas engines are in operation under full load: This quantity, which has previously been cleaned with the bulk of the gas of the furnaces, can be cleaned by four No. 3 Theisen gas washers. A spare apparatus is not necessary, as in case of a shut down of one washer for cleaning or repairs, the three remaining washers will easily take care of the total quantity of gas. Each apparatus would be directly coupled to a 70 b.h.p. electric motor running at a speed of about 450 r.p.m.

Between the gas main and the Theisen apparatus, there should be inserted a pressure regulator which automatically shuts off the entrance of gas to the cleaning plant in case of a lack of gas, thus avoiding a vacuum in the main gas-conduit, and consequently preventing the entrance of air into the latter, which might produce dangerous explosive mixtures in the pipe line. Each apparatus would deliver the clean gas into the water separator situated in front of the gas washer. These separators take out the water from the gas and deliver clean, cool and dry gas into a collecting pipe, which, in turn is connected to the gas main situated around the engines. All piping for connections of the various items of the cleaning plant as well as all water piping is included in the price.

A light steel frame building with brick walls and solid roof is sufficient to shelter the gas washers, their motors and the water separators. This building would be about 100 ft. long and 30 ft. wide, and should be provided with a traveling crane of 5-ton capacity and 30-ft. span.

Surrounding the engines and in the building there should be installed a ring gas main of about 4 ft. diameter, from which the engines take their supply of gas. This ring-conduit avoids all possible interference between the gas streams leading to the various engines and secures a uniform supply of gas. No connection between this gas main and the gas cleaning plant has been considered in this estimate, as it depends upon the local conditions and arrangements.

The building for the gas engines would be about 85 ft. wide and 250 ft. long. It should be a steel structure with brick walls and slate roof, with hardwood floor and provided with runways for the electric traveling crane.

Each 1,500-h.-p. gas engine requires about 10,000 cu. ft. of concrete. The price includes foundations for eight engines and all the iron work, such as foundation bolt washers, girders, supports for piping, etc.

An electric traveling crane of about 25 tons capacity and about 85 ft. span with main and auxiliary trolley would be required.

The price as given for the gas engines would include all the necessary auxiliary apparatus, such as electrically driven barring devices, pumps operated by the main shaft of each engine for circulation of water under pressure through pistons and piston rods, complete piping, etc. It would also include governors having special hand-operated regulating devices for synchronizing the engines, and fly-wheels of sufficient size, which, together with the revolving element of the generators, would assure such a close regulation as to synchronize and run the generators in parallel without difficulty. Modern double-acting tandem gas engines will give 1 b.h.p. on 9,000 B.t.u. or 100 cu. ft. of gas, at full load; 10,000 B.t.u. or 112 cu. ft. of gas, at three-quarter load; and 12,600 B.t.u. or 140 cu. ft. of gas, at half load.

The price of complete piping covers all the

piping for gas, air, exhaust, compressed air and water inside of the engine building and connections to the gas main and also includes two exhaust mufflers with stacks and compressed air tank on each engine.

The air compressor outfit would consist of two electrically driven 2-stage air compressors having a capacity of 150 cu. ft. of free air per minute each, compressing against 150 lb. to the square inch. A main compressed-air reservoir with safety valve and gauges is included in the price. The capacity of each compressor outfit would be ample to permit the simultaneous starting of two engines.

The electrical equipment would comprise eight 800-kw., three-phase, 25-cycle, 6,600-volt generators, two exciter units, driven independently, the switchboard, and the complete wiring between generators and switchboard.

**Operation.**—For cleaning 1,000 cu. ft. of gas per minute, the Theisen apparatus requires a maximum of 12 gal. of water. The part of the cleaning plant chargeable to the power house has to clean a maximum of 1,200,000 cu. ft. per hour, requiring 345,600 gal. of water per day. At 10,500 b.h.p. rated capacity of power plant, the requirements of cooling water for the engines will be about 2,154,000 gal. per day. This makes the total quantity of water per day, 2,500,000 gal. The blast furnace plant being supposed to be located near a stream of water, the cooling water could be provided from the pumping station of the plant at a very low cost of pumping, say at 2 cents per 1,000 gal. At this rate, the total expenditure for water per day would be \$50, or 0.02874 cent per kilowatt-hour. At three-quarter load this figure will be 0.03514 cent, and at half load 0.04236 cent.

According to actual performance of large gas engine power plants, the plant of 10,500 b.h.p. in operation, including electrical equipment and auxiliary machinery, will not consume more than 2 grams of lubricants per b.h.p. hour, 1.2 gram of which will be cylinder oil at 35c. per gallon, and 0.8 gram engine oil at 20c. per gallon. The oil and grease per kw-hour at full load will therefore be 0.02460c. At three-quarter load it will be 0.02922 cent, and at half load 0.04219 cent.

Although the item depreciation and maintenance of the gas power plant covers certain repairs on the machinery, and as small repairs would have to be made by the operating personnel inside of their regular working hours, it is usual to figure on a separate item for repairs on machinery, providing for accidents which might require the replacing or repairing of certain parts of the machinery. Experience with large power plants in Europe indicates that repairs of this kind do not exceed about 2½ per cent. per year of the purchase price of the gas engines and generators. For the gas cleaning plant, 7 per cent. may be assumed, for the air compressor, 5 per cent., and for piping and crane 2 per cent. will cover necessary repairs on these items. The repairs per kilowatt-hour will thus be 0.02834 cent at full load, 0.03362 cent at three-quarter load, and 0.04852 cent at half load.

The power plant when running at its full load capacity will require the following attendants: 1 chief engineer, \$3,000; 1 assistant, \$1,800; 8 machinists for gas engines, \$10,513; 10 helpers, \$9,198; 2 machinists for gas cleaning plant and compressors, \$2,190; 4 dynamo tenders, \$3,942; 4 switchboard tenders, \$3,504; 1 bookkeeper and clerk, \$1,200; total per year, \$35,346. This is equivalent to 0.05566 cent per kilowatt-hour at full load, and by laying off some of the men, to 0.06953 cent at three-quarter load, and 0.10020 cent at half load.

It is generally assumed in computations determining the operating cost of a blast furnace gas power plant that the blast furnace gas has no

value, so that the item "cost of fuel" is generally omitted in such calculations. This, perhaps, might have been permissible formerly when the blast furnace gas was used in the condition in which it left the standard dry dust catchers containing immense quantities of dust, thus restricting considerably the field of utilization of these gases. In modern blast furnace plants, all the gas will be subjected to a thorough cleaning process, which entails certain expenditures for installation, power, maintenance, and attendance for the gas cleaning plant. It is, therefore, only fair to appraise the blast furnace gas which is used for operating gas engines.

Let us assume that the price of coal delivered into bins at the plant is \$2.75 per ton, that the coal has a heat value of 13,000 B.t.u. per pound, and, further, that steam of 150 lb. pressure is raised by burning this coal under boilers. One pound of steam will then contain 1,225 B.t.u. from 0° F. Assuming feed water at 79°, there would be required 1,155 B.t.u. to generate 1 lb. of steam of 150 lb. pressure. In a boiler plant having 65 per cent. efficiency, 1,000 lb. of coal could raise 7,300 lb. of steam. The value of 1,000 lb. of steam would be 18.8c. To this must be added for labor and maintenance approximately 1c. per 1,000 lb. of steam, making the total value 19.8c. 1,000 cu. ft. of blast furnace gas have a heat value of 90,000 B.t.u., and are equivalent to 51 lb. of steam, which in turn are worth  $51 \div 1,000 \times 19.8 = 1c.$  The value of 1,000 cu. ft. of blast furnace gas would, therefore, be 1c. and will develop 10 h.-p.-hours. The value of the blast furnace gas consumed per b.h.p.-hour will therefore be 0.1c. Fuel per kw-hour at full load is worth 0.1448c., therefore, 0.1629c. at three-quarter load and 0.1944c. at half load.

**Conclusions.**—From the above computations, it will be seen that a power plant of about 10,500 b.h.p. capacity complete in every detail and installed in connection with a blast furnace plant, would be capable, when running at full load capacity, of producing 1 b.h.p. per year at the low cost of \$17.88, no value being placed on the blast furnace gas. The enormous saving as compared with the production of power in a steam engine plant is still more striking, when the cost of generation of electric current is considered. Ac-

OPERATING CHARGES OF POWER PLANT, PER HORSE-POWER-YEAR.

| Load            | Full    | ¾        | ½        |
|-----------------|---------|----------|----------|
| Fixed charges   | \$9,524 | \$12,500 | \$20,000 |
| Water           | 1.783   | 2.116    | 2.672    |
| Oil, grease     | 1.490   | 1.760    | 2.660    |
| Repairs         | 1.714   | 2.025    | 3.060    |
| Wages, salaries | 3.366   | 4.187    | 6.320    |
| Total of above  | 17,877  | 22,588   | 34,712   |
| Fuel            | 8.76    | 9.81     | 12.26    |
| Total           | 26.64   | 32.40    | 46.97    |

cording to the above tables, one kw.-hour at full load capacity of the plant could be produced at 2.95 mills, which is away below the best figure ever reached with a steam engine power plant. Even under worse conditions, that is, when the power plant is running on an average of only 50 per cent. of its total capacity, the cost of generation of one kw.-hour is but 5.50 mills. It is evident that an eventual increase in the capacity of the power plant would still tend to reduce the cost of the generation of power per unit, as certain expenditures for the power plant of 10,500 b.h.p. would remain unchanged for additional power units.

A 5-TON AUTOMOBILE COAL TRUCK has recently been placed in service by a large coal company in Chicago, for delivery of coal in the loop district of that city. It is equipped with a 10 h.-p. electric railway type of motor and has 40 storage battery cells which give a range of travel of about 30 miles per charge. Six loads of 10,000 to 11,500 lb. are delivered regularly per day with ease as against three to four of not over 8,500 lb. with the usual three-horse teams.

### Mechanical Plant of the Hotel Belmont, New York.—III.

**Electrical Equipment.**—The generating plant of the Hotel Belmont was described in the first article of this series. There are four engine-driven units, three of which are of 200-kw. capacity and the fourth of 150 kw. Each has a tandem-compound, medium-speed Fitchburg engine, direct connected to a multipolar, compound-wound, direct-current Western Electric generator. The generators deliver at 120 volts, this lower voltage being preferred for hotel purposes to the higher voltages coming into quite general use in commercial buildings. The plant was given a considerable excess of capacity over average requirements, it being capable of carrying at rating a total load of nearly fifteen thousand 16-c.p. incandescent lamps or their equivalent. There are actually connected about eleven thousand lamps, and a motor load aggregating in all 252 h.-p., making the capacity of connected apparatus practically equal to the total rated generating capacity.

Current is delivered from the dynamos by lead-covered, paper-insulated cables beneath the floor to a large marble switchboard at the Park Avenue side of the engine room, from which the distribution system is controlled. This board contains two generator panels, one instrument panel, and six for the 87 feeders. Each generator panel has two field rheostats, two Weston ammeters, two I. T. E. circuit breakers and a voltmeter switch. The switching scheme permits either ammeter to be thrown on either generator, or both on one generator, the latter scheme being used in tests to compare the two ammeters. Of the six feeder panels, three are for lighting feeders and the others for both lighting and power circuits. The board was built by the H. Krantz Mfg. Co. for the Western Electric Co.

The hotel is wired nominally on the two-wire system for operation exclusively from the single-voltage generators of the power plant, but has a large number of the feeder circuits arranged for operation on the three-wire system if this should become desirable. The latter consist of lighting circuits of approximately even loadings with the negative conductors joined into one cable of large size, which would form the neutral in case of three-wire operation. Nothing is saved by this for two-wire operation, but it is operative for either system and is of value for its adaptability to the three-wire system at any time. This has been applied to lighting circuits only. Of the 87 feeder circuits, 22 are for power purposes, all in the basements with the exception of one feeder which rises 450 ft. to the deck house on the roof to operate the ventilating fans and hand laundry machinery. The remaining 65 circuits extend to the panel boards throughout the building, from which the local distribution is made. The arrangement of the feeders supplying the upper floors of the hotel and their connections to the panel boards are shown diagrammatically in an accompanying engraving.

There are 18 of the guests' room floors supplied by the lighting feeders, each floor having 38 rooms and a total of 445 incandescent lamps and 24 curling-iron heaters connected, and 16 of the rooms have baseboard plug connections for extension cords. For their supply there are 33 feeders carried up from the switchboard, which are divided into five groups leading to local panel boards in the different sections of the building, in order to reduce to a minimum the lengths of local circuits to the rooms. The building divides naturally into five sections, and in each there is a riser shaft carried up from the second to the twenty-first floor with openings into the halls for connections to the panel boards. These

risers and their sections of the building have been designated by the letters A, B, C, D and E, as indicated in the half plan of the typical bedroom floor and also in the feeder diagram. The principal feature of the wiring of these upper floors is that each feeder supplying room lighting is carried direct from the switchboard in the power plant up to the feed points, which consist in most cases of three panel boards upon consecutive floors of the section served. The individual feeders enter panel boards on the third floor and every third floor above that one, and after passing through them rise to the two other boards of the group on the floors above, as shown in the diagrams. This plan is carried out for all five sections and for all floors, except that in risers A, D and E, the eighteenth and nineteenth

of these supplies the greater part of the corridor lighting in its half of the building from the second to the tenth floor, while the other similarly serves the upper floors from the tenth to the twentieth, the third being a special circuit which extends throughout the entire building on either side to supply a limited number of all-night lamps in all corridors. The building laws of the city require gas jets in every corridor of a hotel, and on every combination chandelier, G, placed in the corridors to meet this regulation, there is also a lamp on this special circuit. Both the regular corridor lighting and the special circuits are controlled directly from the power plant switchboard, the former being carried through the evening, until at a certain hour they are cut off and the special circuit lamps lighted for



and the twentieth and twenty-first floors are fed in groups of two each in the order named instead of three. The method of carrying separate feeders to each group of three boards prevents the differences of drop that would occur if a greater number of panel boards were supplied per feeder. The design of the distribution system has been, in general, to secure a drop of not more than 3 volts from the generators to the panel boards, or of not over 4 volts from the generators to the farthest lamps. In practice, it is anticipated that these maximum drops will rarely be reached inasmuch as all lights connected will be rarely if ever lighted at the same time; where circuits are to be heavily loaded, feeder capacity has been provided to keep the drop under such conditions well below 4 volts.

The hall lighting, which is supplied through risers B and C only, is entirely different, having three feeders in each to supply all corridors from the parlor to the twenty-second floor. One

the all-night service. There are 10 special lamps on each floor, while the regular corridor lighting has 53 lamps upon 21 chandeliers, 10 of which have the gas and special circuits. The service corridor lights are supplied from the local lighting panel boards with switch control at each floor.

The room lighting is in general wired upon the plan of one circuit for each room, although in cases of the larger and more important corner rooms there are two circuits; there are in all 43 room circuits for the 38 rooms upon each typical floor. The longest room circuit from any panel board is less than 100 ft. in length. In all main rooms, and also bath rooms, the principal chandelier is controlled by a switch at the corridor door, while in all the more important rooms individual lamps in clothes closets are controlled automatically by door switches, which turn on the light whenever the door is opened. There is an electric curling-iron heater in every bath room and a side bracket lamp placed alongside the

bed location; where the latter is not provided, there is a baseboard plug connection for an extension cord and portable lamp. All the local wiring from the panel boards is carried in "electroduct" with Krantz outlet boxes.

Each guest's room is equipped with an electrolier in the center carrying from three to six lamps, and generally three single-lamp, side-wall brackets,  $5\frac{1}{2}$  ft. above the floor, two located  $4\frac{1}{2}$  ft. apart, for opposite sides of dressers or pier glasses and the other at the head of the bed location. The inside rooms have three-light elec-

one lamp per each 36 sq. ft. of floor area, exclusive of the portable lighting that has been provided for.

The total capacity of motors connected is 252 h.-p., about half being for ventilating and fresh air supply fan drives, the former requiring a total of 38 h.-p. and the latter 85 h.-p., or 123 h.-p. together. There are over 40 h.-p. of motors in direct-connected drives on laundry machinery in the third basement, while in the kitchen, bakery and storerooms, there is over 30 h.-p. in motors for the driving of dish-washing

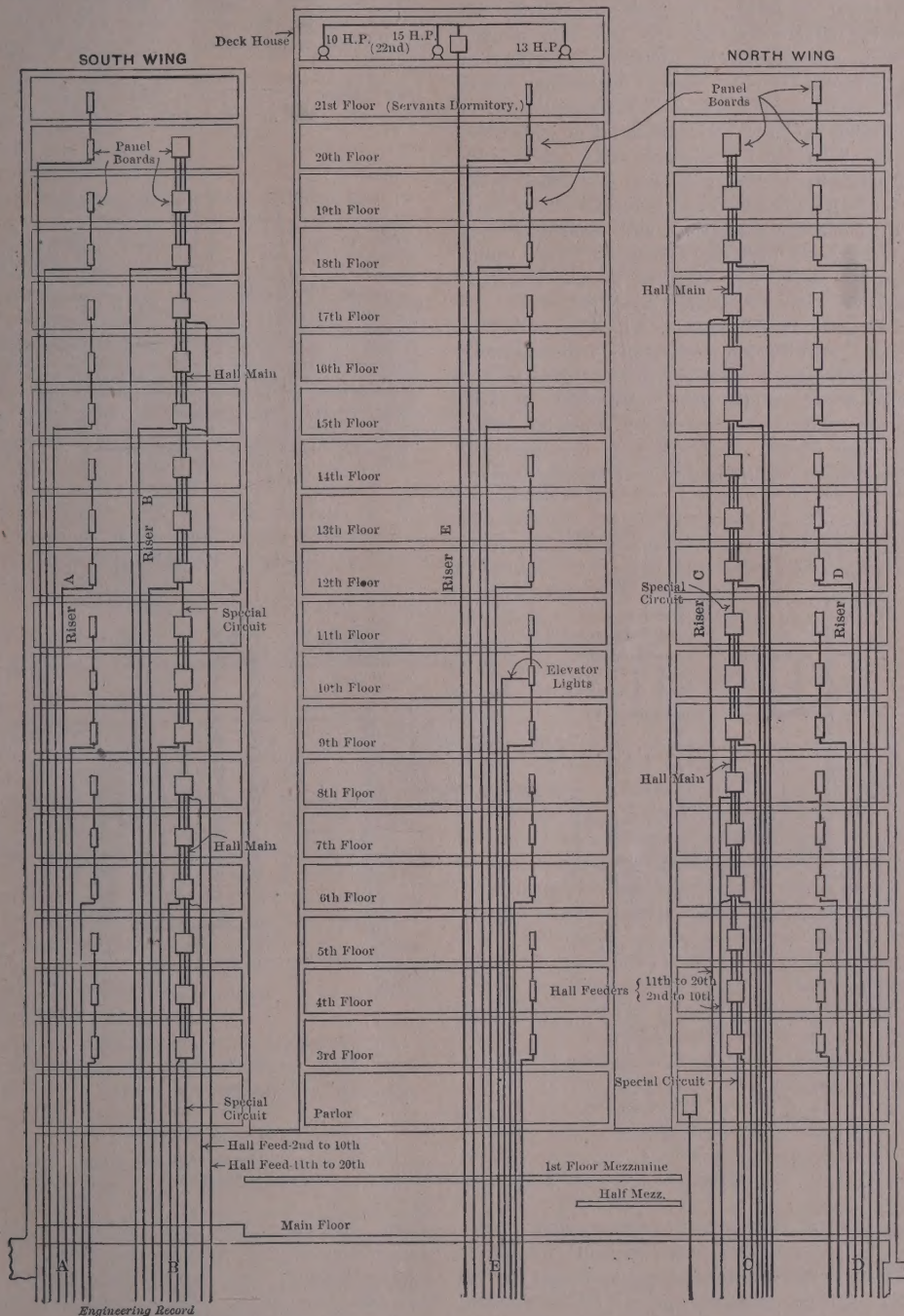
the hotel were Clark & MacMullen, New York, who also designed the engine and generating equipment to which reference was made in the first article of this series. The contractor for the electrical installation, as well as also the auxiliary electrical equipment, was the Western Electric Co. All wiring has been placed in metallic conduit, for which there was used in all nearly 263,000 ft. of electroduct, supplied by the American Circular Loom Co.; of this the  $\frac{1}{2}$ -in. size predominated, there being over 210,000 ft. of it used; there was 26,500 ft. of the  $\frac{3}{4}$ -in., and 11,000 ft. of the  $2\frac{1}{2}$ -in. size, the latter being mainly for heavy feeders. For the outlet connections, 10,443 outlet boxes were installed, which, together with the panel boards, were supplied by the H. Krantz Mfg. Co., Brooklyn. For the wiring systems over 620,000 ft. of insulated wire in the various sizes was used, of which 80,000 ft. was for the low-voltage auxiliary electrical service.

**Auxiliary Electrical Equipment.**—In addition to the power and lighting equipment, a variety of auxiliary electrical apparatus has been provided. For communication between the guests' rooms and the office, the usual private branch exchange telephone system will be used, but an innovation in it is the installation of a new type of flush instrument in the guests' rooms, the cases for which are set in recesses in the walls. There are duplicate fire alarm systems, a watchman's time detector system, and electric clocks by which the time is accurately indicated in all parts of the building. Another innovation will be the extensive use of the telautograph for issuing written orders to employees in all parts of the building, a new departure in hotel service, while it is also proposed to establish a wireless telegraph station on the building for convenience of the patrons.

Current for this auxiliary equipment is supplied by a low-voltage system of large capacity, consisting of a 10-kw. Western Electric motor-generator, operating on the 110-volt power system to deliver 20 volts, and two 40-amp.-hour sets of chloride storage battery of 10 cells each, which may be used alternately or together or be replaced by the motor-generator set, as desired. The connections are flexibly arranged to prevent a shut-down and permit of changing from one source of supply to another without interruption. The supply is usually taken alternately from the storage batteries, the discharged set being charged in the meantime ready for its next turn.

The New York Telephone Co. is furnishing the hotel with one of the most complete private branch exchange systems ever installed, the equipment of switchboard, distributing frames, ringing, power and testing apparatus making the plant a complete central exchange in itself, independent of any assistance. The switchboard is located in the mezzanine gallery over the lobby and consists of two three-position sections. It provides for 960 local telephone connections in the building. There are 40 trunk connections, with capacity for more if needed, to the Thirty-eighth St. central exchange of the Telephone Co., and under maximum service from five to six operators will be required. The terminal plant is located on the laundry, or third basement floor, and has the distributing frames for both the local connections in the hotel and the trunk lines, the relay rack, fuses, the ringing machine, motor generators and a set of storage batteries, in a separate enclosed room. There is also a wire chief's desk here, enabling all necessary testing to be carried out.

All lines in the building, both from the terminal frames to the switchboard and to the various instruments, are carried in conduit throughout, riser shafts being provided for this purpose alongside of all of the lighting feeder risers to



Feeder Riser Diagram for Electric Lighting of Guests' Rooms Floor.

trolers, while the front rooms have 4 and 5 lamps, and the corner room chandeliers 6 lights. In all bath rooms and in the wash-stand closets of rooms without bath there are two-light side-wall brackets, each controlled from a switch just inside the door. Illumination provided for the guest's rooms ranges from one lamp to each 39 sq. ft. of floor area up to one lamp to 22 sq. ft., the average being 33 sq. ft. The averages for the inside rooms run slightly higher than for those fronting on the outside inasmuch as the former are in all cases considerably smaller. The total lighting of each typical floor, including bath room, closet and corridor lighting, amounts to

machines, mixers, ice cream freezers and the like. The balance of the motor equipment is distributed in small units in various sections of the building, including several motor-generators for low-voltage supply, battery charging. C & C motors are used in most cases, each controlled through a small panel board located near it with double-pole fused switch and single-pole circuit breaker.

Practically no arc lamps are used, with the exception of a few in the boiler and engine room, even the outside decorative lighting being accomplished by incandescent lamps.

The engineers for the electrical equipment of

the upper floors. On every floor the risers have outlet boxes from which the branch connections to room instruments are readily made, the latter being also carried through conduit. The guest room telephones are of a very compact design arranged to set into the outlet boxes of the system, so that the transmitter and the receiver on its hook are the only parts projecting beyond the front surface of the case. The solid-back transmitter, together with all other details of the standard long-distance set, are used, the entire system conforming to the standards of equipment of the common-battery system now used by the company.

There are two distinct fire alarm systems installed, one communicating with the hotel office and the other connected with the city system so as to trip the nearest city fire alarm box. For the latter system, the Manhattan system of house boxes is used, one of which is installed on every bedroom floor and in all important sections of the building, so as to be easy of access. These are operated on the multiple open-circuit system, and in tripping the city alarm box are independent of the hotel office, other than indicating upon an annunciator the location of the house box pulled.

The local hotel fire alarm system, which communicates only with the office, has a glass-covered push-button equipment, in which the glass must be broken in order to send the alarm. Of these boxes there are three on every bedroom floor and others distributed frequently throughout the building. These communicate with an annunciator board in the hotel office, so that in the event of an alarm the clerks in attendance may at once investigate the extent of the trouble in order to alarm the city department if necessary. There is installed in connection with these local alarms a gong system for alarming the guests, which is controlled by a compound switch in the hotel office. There are in the corridors upon the upper floors and in all more important portions of the buildings, 76 large electric gongs, and the compound switch permits any one of them to be rung separately, or in any grouping that may be desired.

For the watchmen's time detector service an Eco equipment is being installed, in which the usual magneto and crank type of station is replaced by a special key switch, the watchman carrying the key for insertion at each station. There are 55 stations on the upper floors, their arrangement in the various corridors being such that the watchman cannot possibly visit all of the stations without entering or passing through every corridor. There are two stations on every bedroom floor, their arrangement being such that the watchman, after completing a floor, passes down the nearest end stairway in one of the wings and must thence pass entirely around the building in order to visit the furthest stations, a fortunate arrangement of corridors making this possible with not more than two stations per floor.

An auxiliary to the telephone system has also been installed in the form of a bell call system for the employees, push buttons being located at frequent intervals in the corridors, lobby and lower floors, in order to permit them to communicate signals to the office. For this there is a 100-drop annunciator in the office in the lobby.

The system of electric clocks consists of an accurate master clock from which 26 secondary clocks are operated electrically in synchronism. The master clock, located in the office of the engineer of the building, is of the second-beat pendulum-regulated type and has a self-winding attachment by which rewinding of the mainspring occurs every minute as long as the 20-volt current supply is available, so that a uniform tension is maintained constantly in the spring. The master clock has a mercurial-compensated pen-

dulum weight for the highest possible degree of accuracy in regulation.

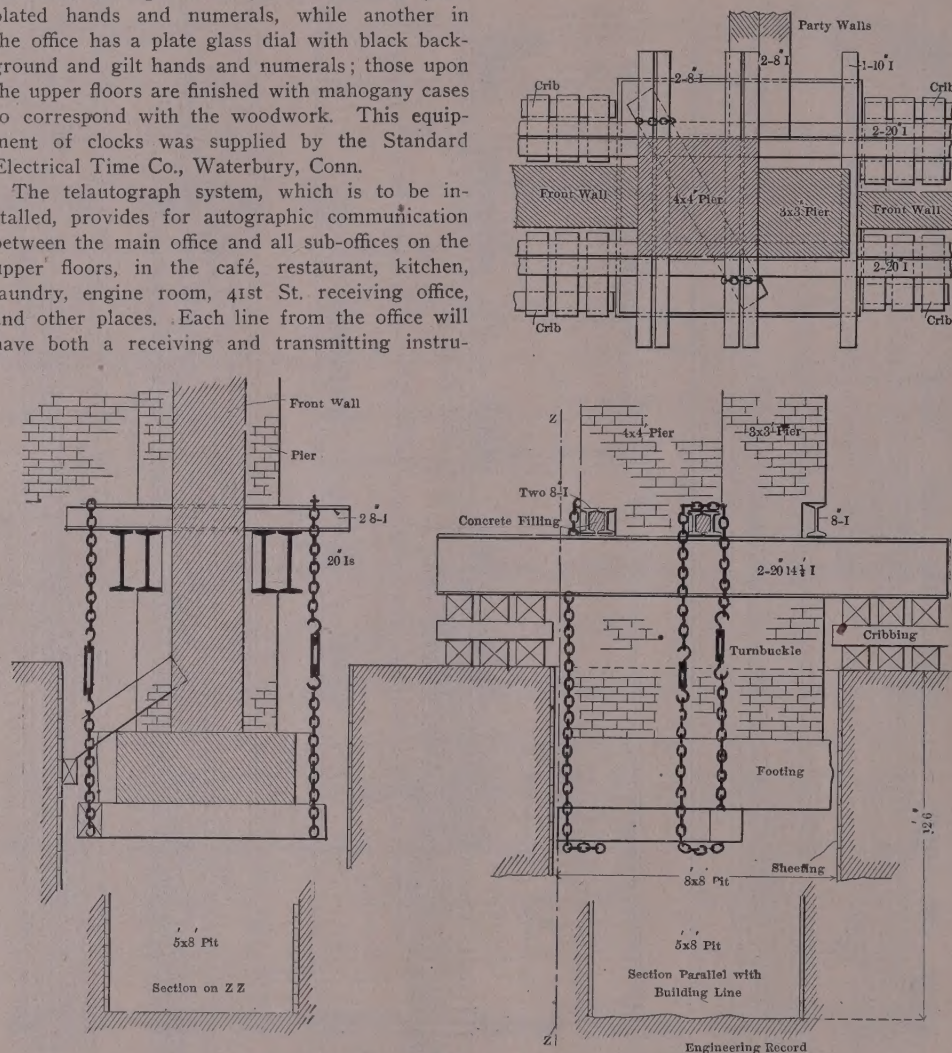
The secondaries are distributed in the sub-offices, one of which is located on every third bedroom floor, in the lobby, dining rooms, kitchen and other leading rooms. They are operated from the master clock in three separate series circuits, which are closed regularly once a minute by the master clock, causing the secondaries to follow it in one-minute jumps and thus keep in absolute synchronism. The secondaries have simple magnet-operated movements, with a detent movement preventing the minute hand from advancing either more or less than one minute, even in case of extreme variations of voltage of the operating current. Special ornamental effects have been adopted for the secondaries, one in the lobby having a 20-in. marble dial with gold-plated hands and numerals, while another in the office has a plate glass dial with black background and gilt hands and numerals; those upon the upper floors are finished with mahogany cases to correspond with the woodwork. This equipment of clocks was supplied by the Standard Electrical Time Co., Waterbury, Conn.

The telautograph system, which is to be installed, provides for autographic communication between the main office and all sub-offices on the upper floors, in the café, restaurant, kitchen, laundry, engine room, 41st St. receiving office, and other places. Each line from the office will have both a receiving and transmitting instru-

## Underpinning Brooklyn Stores.

The excavation for one of the stations of the Brooklyn branch of the New York Rapid Transit Railroad is made on both sides of a four-track subway and has a length of about 350 ft. and depth of 23 ft. It occupies nearly all the space between the building lines in front of a number of stores on opposite sides of the street and extends so far below their footings that the front walls have had to be underpinned and some excellent and interesting work has just been done in building the new foundations and in sustaining the old walls and columns during the operation.

The large stores at No. 450 and 452 Fulton street are four and five stories and basement in



Plan and Sectional Elevations Showing Underpinning Methods.

ment for written communication in either direction, but no provision is to be made for interconnection of the various lines centering at the office, it being required that all such messages pass through the office. These instruments will operate on the 110-volt current supply from any lighting outlet, three wires being necessary between the office and each station.

(To be Continued.)

A COMBINED HORIZONTAL AND VERTICAL ENGINE of the compound Corliss type has recently been built for the Tennessee Coal, Iron & Railroad Co. by the Mesta Machine Co. of Pittsburgh, Pa. It has a 44-in. horizontal high-pressure cylinder and a 72-in. vertical low-pressure cylinder with a common 60-in. stroke and at 85 r. p. m., one-half cut-off, and 150 lb. steam, develops 6,500 i. h.-p., its maximum capacity being 10,000 h.-p. It drives a rail mill at Ensley, Ala.

height and have brick walls carried on steel beams supported by columns and piers. Their separate footings were carried down about 4 ft. below the floors of the cellar and sidewalk vaults and about 11 ft. below the level of the curb and were seated on a deep stratum of fine, dry sand. Where the two buildings are adjacent their front corners have rectangular brick piers about 4 ft. and 3 ft. square respectively, with the sides on the lot line in contact, but not bonded together. The pier masonry was however, bonded into the thin brickwork of the front and party walls which intersected them at right angles, thus forming a double pier which is T shape in horizontal cross section with the walls.

The vault floor was removed, an excavation made under it 2 or 3 ft. to solid, dense sand, and on it a timber crib was built close to the face of the basement wall about 6 ft. each side of the center of the double corner pier. Similar piers

were built symmetrical with these on the basement floor inside the wall and on each pair of cribs were leveled up two 20-in. I-beams 14½ ft. long parallel and close to the face of the wall. A horizontal slot or recess about 11 in. high and 10 in. deep was cut across the outer transverse face of the pier in the five-story building, a somewhat smaller one was cut across the opposite face of the adjacent pier and a 9x9-in. hole was cut through the wall on the center line between the two piers. Through the 9x9-in. hole was passed a pair of horizontal 8-in. I-beams; a pair of 10-in. I-beams was fitted into the first slot in the side of the pier and a single 10-in. I-beam was placed in the other outside slot. The spaces between the ends of the webs of the two pairs of I-beams were temporarily closed and grout was run in and filled the rectangular space enclosed by webs and flanges, thus making a solid needle beam. The ends of the three needle beams were wedged to bearing on the 20-in. I-beams and hydraulic jacks were operated in the cribwork under the ends of the latter until they bore the full weight of the piers and commenced to lift them.

A pit 8 ft. square was then started between the cribs and under the wall and was carried down about 6 ft., sheeted with horizontal planks worked in from the bottom, and suspended from above. A second pit reduced to 5x6 ft. was started in the bottom of the first pit and carried down to a depth of 12½ ft. below the basement floor, or to the level of the bottom of the subway excavation, and was sheeted like the upper part. A 10x10-in. timber with the ends secured to the projecting ends of the needle beams by loops of 1-in. chain was first worked horizontally under the footing. The chair was provided with pairs of long turnbuckles and wedges with which it was brought to a good initial tension. The lower part of the pier was also braced by an inclined timber and the excavation was completed and a new concrete footing built in the bottom of the pit. A brick pier was built on the footing and pairs of granite templates on it were wedged to bearing against the under side of the sound masonry of the old pier and thus transferred the whole pier and column load to the new footing which after some delay to allow for settlement and compression was grouted up and the pit back-filled. There are in all about 30 single and double piers in this locality which are being underpinned in substantially the manner here described by an average force of 10 men who did all the work for a single pier in a minimum time of about 5 days.

The work is being done by Cranford & McNamee, the contractors for the subway construction at this point. Mr. R. N. Cranford is in charge of the underpinning.

A HIGH CHIMNEY has recently been built in Newark, N. J., for the Heller & Merz Co. It is 350 ft. high, 27½ ft. in diameter at the bottom and 9 ft. 10½ in. at the top, the inside dimensions being 20 and 8 ft., respectively. It is built of brick with concrete foundation, and outside of its height its most interesting feature is the heavy piling for supporting the foundations. The site of the chimney is covered by 4 ft. of miscellaneous filling underlaid by 6 in. of semi-peat and 18 in. of clay. Below this are 10 ft. of sand and below this soft clay to a depth of 60 ft. below the surface. The concrete base, 14 ft. thick, contains about 800 cu. yd. of concrete and rests on 324 yellow pine piles. These were 60 ft. long before cutting off and placed on 2½ ft. centers over an area 45 ft. square. They were cut off from 3 to 10 ft. after driving, and their tops are embedded 1 ft. in the concrete base. This stack is within 10 ft. of the height of the chimney of the Orford Copper Co., Constable Hook, N. J., described in this journal Jan. 26, 1901.

### Book Notes.

The importance of high-temperature measurements in scientific and industrial work at the present time is shown by the fact that it has been necessary to bring out a second edition of Dr. Burgess's translation of Le Chatelier and Boudouard's "High Temperature Measurements." Since the appearance of the first edition there have been great advances in optical pyrometry, and this portion of the book has been much enlarged in consequence, a chapter on radiation being inserted in order that the laws employed in this class of apparatus may be properly understood. In the high temperatures attained in electric furnaces, resistance pyrometers cannot be employed, and the optical instruments become indispensable. They are comparatively new, however, at least in commercial work, and there are some features concerning them which it is unfortunate that this book does not clear up, such as the accuracy of the instruments when the interior of the furnace contains vapors which may cut off a part of the light. The book will be found of much value by engineers who have to make high temperature measurements, as it gives a concise explanation of the principles and apparatus employed in such work. (New York, John Wiley & Sons; \$3.00.)

One of the most interesting books written by an engineer since the appearance of Mr. William Barclay Parsons's account of his railway surveys in China is the "Thibet and Turkestan" of Lieut. O. T. Crosby. The author attempted to reach the Forbidden City, but actually did not get very close to it. He left Polu on the border of Chinese Turkestan, but after a series of misfortunes became lost in the White Desert, in the extreme northwest corner of Thibet. Here he was found by some friendly Kirghiz, who refused to help him toward the Lhasa, but assisted him in reaching Kashmir, where he gave up the attempt to reach the heart of Thibet and went over the Srinagar Pass to Rawal Pindi and the railways of civilization. While these travels were not particularly interesting from their geographical results they showed the hazards of exploring in that part of the world and the account of them is entertainingly told. A large part of the book is a discussion of political topics relating to Thibet. The author believes that Great Britain has not been well informed by her advisers who said that India could be defended against a northern invasion by establishing outposts in Thibet. He also looks with apprehension on the infringement of Chinese authority by the advance on Thibet, holding that Russia will be forced to make similar advances in Chinese Turkestan, and the Celestial empire will be accordingly threatened from the West by two powers whose mutual distrust of each other may lead to serious international complications. The resources of the country, so far as export and import business is concerned, are declared to be almost nil. (New York, G. P. Putnam's Sons.)

One of the best discussions of hollow concrete block construction in all its details is Mr. S. B. Newberry's "Concrete Building Blocks," which has just been published for free distribution by the Association of American Portland Cement Manufacturers, Land Title Building, Philadelphia. This valuable paper was presented by the author before the Association some months ago, and an abstract of it has already appeared in this journal. It has been revised for publication in this pamphlet, and is a reliable guide for a class of work where good guidance is much

needed. The author first explains those properties of sand, gravel, cinders, stone screenings, lime and cement which must be considered in proportioning concrete for blocks, and discusses the effect of different proportions of the ingredients on the strength, permeability and cost of the blocks. Some valuable hints on mixing are then given. The types of concrete block construction are explained and there is an unusually full account of the method of securing waterproof properties by the use of properly graded materials, rich mixtures, facings, impervious partitions, and special compounds. The cost of concrete blocks is discussed in general terms, and some good hints are given concerning the design of buildings made of these blocks. Mr. Newberry points out that anything which savors of imitation, of pretending to be what it is not, will always be hated and condemned by all who know the difference between the good and the bad. The common rock-faced block is an imitation of the cheapest form of quarry stone, and a poor imitation at that, he says, for no two natural stone blocks are alike in surface. Smooth, ribbed and paneled surfaces, also good ornamental patterns for friezes or cornices, are entirely legitimate and equally characteristic of stone, metal, terra cotta or concrete. Forms of beauty may properly be reproduced in any material; the only thing to be avoided is pretence, the attempt to deceive the observer into the belief that the material he sees is something different from what it really is. Mr. Newberry acknowledges that the film of cement which coats the face of the work is monotonous and unattractive, but he says that it can be cheaply removed by washing with very weak acid; this will give beautiful effects, especially with crushed stone or gravels containing pebbles of various colors.

HYDRAULIC MACHINERY. With an Introduction to Hydraulics. By Robert Gordon Blaine. London, E. & F. N. Spon; cloth, 459 pp., 14s.

When the first edition of this book was published it was reviewed at some length in this journal, and it is therefore hardly necessary to explain again its encyclopedic character. It is essentially a description of all classes of hydraulic machinery, and of many types of each class. These descriptions are not of the nature of trade catalogue notices, but real explanations of the principles of the action of the apparatus and in many cases of the chief steps followed in their design. The first portion of the volume is a somewhat more complete explanation of those laws of hydraulics used by the designer of hydraulic machinery than is customarily given in books of this class. For example, there is a discussion of the critical velocity at which there is a change in the law of flow of liquids, and Prof. Osborne Reynolds's experiments illustrating the subject are described. The portion of the book relating to weir measurements is unusually complete, so far as it relates to British studies on the subject, and an example of the method of working out the maximum power of a given fall, based on actual data, is solved step by step.

The portion of the book relating to hydraulic machinery describes water meters, jet propulsion, reaction wheels, water wheels, centrifugal pumps, turbines, turbine power installations, hydraulic presses, hydraulic transmission of power, hydraulic cranes, elevators, hydraulic motors, and hydraulic machinery employed for special purposes like the operation of dock gates, riveting machines, bridge machinery and other heavy objects. There is also a short section on pumping machinery, the pulsometer, the hydraulic ram and other devices for lifting water. Two of the best portions of the book relate to centrifugal

pumps and turbines. Their theory is presented in considerable detail and the principles of design are stated quite fully. Considerable space is given to descriptions of some recent American installations of turbines and to governing apparatus.

### Letters to the Editor.

#### NOTES ON MARSH ROADS AND HAIR CRACKS IN CONCRETE.

SIR: In your issue of Dec. 16 there are two questions raised, one by Mr. Saunders' letter on difficult meadow road construction and the other by the article on hair cracks and crazing of concrete. Several years ago there came under my observation a difficult piece of work in the carrying out of which a more serious difficulty than Mr. Saunders cites was overcome very satisfactorily. The "Valley R. R.," in San Joaquin Co., Cal., now the "Santa Fe," surveyed a cut-off from Stockton to the hills back of Oakland. Several miles of this route was over the tule land, which is virtually floating land. They attempted to put in a trestle, but piling 125 ft. long went out of sight in the bottomless blue mud. They finally hit upon the plan of binding into mattresses or fascines, with wire, the small willow brush found along the right of way. They were spread in a uniform binding plan across the right of way and a stringer to support the ties and rails was laid parallel with the road. Dump cars were pushed onto this and enough dirt was brought up and spread to permit flat cars to be pushed with an engine. In this way a fill was gradually made with a 2 to 1 slope. In some places, where there were old estuaries or water courses, perhaps, there was an appreciable squashing out and settlement, but in the main it was an easy matter to carry the construction along to a successful completion.

I think the first time I saw this method carried out was by Mr. J. S. Polhemus, in government work on the coast of Oregon, where a heavy rock fill, with some stones of 4 or 5 tons in weight, went out of sight faster than they could dump it from the piling jetty, owing to the heavy current and shifting sands. By using the brush method they overcame this difficulty and it was only a year or two until the barnacles and other sea growths aided in uniting the whole thing together and now the jetty is a permanent quay on a sand, and shifting sand, too, foundation.

In Mr. Moyer's article he comes to the conclusion from his own as well as other investigations, that "mortar, composed of one part Portland cement and three parts sand, shows an expansion but less in proportion than neat cement." I maintain that the desired result cannot be secured by the average mixing and chemical setting alone, but that it is by or through a thorough manipulation of materials. A hard coat finish in plastering, unless the putty and plaster are thoroughly worked before applying and well "darbied" and "floated" before troweling, will "craze," no matter how rich the mixture. Likewise in cement sidewalk work. I will take a "lay" of walk and finish it with no "crazing," and alongside it I will make another piece that has the same proportions of material, or even less cement, or more, either way, and it will be so "crazy" that no one would accept it. It is in the crowding or kneading effect of the trowel in spreading and the whipping with the trowel, before the final stroke, that removes all excess air, and, as I figure it out, "tempers" the aggregate much on the same principle as that used by the painter, when he has occasion to add a little lead or whiting to soft putty. This is shown still more completely in the use of willow fibre plaster. If you attempt to float it dry, as you would ordi-

nary lime and sand mortar, you will not get the finish that you will by adding an excess of water and working it until you raise a cream, and then floating lightly until all water creases are worked out and a perfect finish secured, which will not craze, pipe or sand. These things I have learned by personal handling of the tools as well as materials.

In concrete work, I use a sloppy cement grout, not so wet that the water will run off as a stream and carry with it fine cement and sand, but so wet that the concrete will tremble. Then in placing it I always crowd the fine aggregate toward the outside or next the forms and then, in case of facing, I use a 3 to 1 mortar, not too fine a sand, and use a good deal of water. I try to raise a cream, but not float it down with a trowel, preferring to rub it out or brush it out to a finish.

I desire to commend the writer of the letter who recently recited his experiences with American methods of concrete work, especially along the line of waterproofing. I have come to the point where I am considered an expert in this class of work, but it is simply because I pay close and careful attention to details. Too much attention is paid to the stresses in members in design and not enough to the characteristics of the constituent materials and their manipulation. The most exacting specification and careful handling will not prevent a failure from any one of several causes, such as hard water, slickness in sand or gravel, too dry a mixture, careless tamping, putting too much material into the molds at once and trusting to a top tamping to do the work, bonding new to old work, or slipping up or "dove-tailing" the work. Yours truly,

Yreka, Cal.

J. F. LYMAN.

#### SUBWAY RAILROAD VENTILATION IN LONDON.

SIR: The accounts that have appeared in your paper regarding the condition of the air in the New York Subway railroad make it probable that the experience on this side in our tube railroads may interest American engineers. Our tube lines are not like your subway, with its single wide multi-track thoroughfare, broken only by longitudinal rows of columns, for here each line consists of two parallel circular, single-track tunnels, one for the down trains and one for those moving in the opposite direction. The cars fit these tubes so closely that they act as pistons in moving the air. In the case of the City & South London road, which was first opened and is not carrying very heavy traffic, the movement of the air effected in this way keeps the condition of the cars and stations fairly satisfactory, although, of course, there will always be free-born Britons who will exercise their prerogative of complaining of every condition in such a road.

The situation has not been so satisfactory in the tunnels of the Central London Ry., which carries a heavier traffic. Although the piston effect of the trains is said to give the air in the tunnels a velocity exceeding 20 ft. per second at times, it becomes very dead during the times of heavy traffic. In order to remedy this condition, a large mine fan was installed at the Shepherd's Bush terminal of the line. After the trains stop running at night, all the station entrances are closed and this fan is started up, sucking in air at the Bank terminal station about 6 miles distant. In this way the whole tunnel is filled with fresh air before the trains begin running in the morning. It is only a partial remedy, for experience shows that the amount of air entering the stations by natural means during the hours of operation is not enough to overcome the foulness that follows the use of the railway. It is stated that the amount of carbon dioxide in the air never reaches the so-called normal allowance of 13 parts per 10,000, but there can be no question that

the air becomes exceedingly unpleasant to breathe.

Other methods of ventilating are being introduced. On the Great Northern & City Ry. the system of shafts which has been used to such advantage on the Mersey tunnel has been adopted. Ordinarily it is too expensive, not only on account of the cost of constructing such deep shafts as are needed to reach our London tube railways, but also because the surface rights for their outlets would ordinarily be very expensive. In the case of the railway named, advantage has been taken of the presence of a feeder cable shaft at the site of the power station to furnish such a means of ventilation.

The most interesting remedy that has yet been tried is that of the Baker St. & Waterloo Ry., where Mr. J. R. Chapman, the chief engineer, has provided at the vertical stairway shaft of each station a large exhaust riser running up to an electrically operated exhaust fan. The base of this vertical duct is connected by a duct below the floor of the passageways with the farthest end of the station platforms and thus sucks out the foul air in the stations. The fan equipments have been designed to change the air in both tunnel stations once in 30 minutes, the fresh air entering through the passages by which passengers gain access to the stations from the street. There was some debate at first whether it were best to use an exhaust system, or to force fresh air into the tunnels and allow the foul air to pass out through the passenger exits. There were several objections to the latter system, however, the most important being the possibility that in case of fire in the tunnels the smoke would be forced along the same passages the people would use in escaping from the tunnel, instead of by independent ducts as is the case in the adopted system.

Sincerely yours, JOHN FEATHERSTONE.  
London, December 29.

### Interstate Water Rights.

Interstate water rights have recently been reviewed by the U. S. Circuit Court of the Northern District of California in *Anderson v. Bassman*, 140 Fed. Rep. 14. In California the common-law rule of riparian rights governs the use of water from a stream for irrigation, each riparian owner having the right to make a reasonable use of a reasonable quantity of water on his land. In Nevada the rule of priority of appropriation governs, without reference to whether or not the lands are riparian. This suit was to determine the rights of citizens of Nevada and California to the waters of the West Fork of the Carson River, which rises in Alpine county, Cal., and flows into Douglas county, Nev. The court decides that riparian owners of lands on a stream in California and appropriators of waters for irrigation purposes from the same stream lower down in Nevada were equally protected in the rights given them by the laws of the respective States, both subject to the limitation that a reasonable quantity of water only for the beneficial use to which it was devoted should be taken; that it should be economically distributed, and the surplus unused returned to the stream; that where the quantity of water in the stream was at times insufficient even for the users in California they would be restrained from diverting water from the stream during such part of the time as would give to the lower users in Nevada their just share.

BASIC BESSEMER STEEL will be permitted in the bridges of the Austrian State Railways, according to "The Engineer," of London. Until recently only open-hearth steel was allowed in such structures.